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REPORT OF FY81 EFFORT FOR PIFS-N MODEL.(U)
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NORDA Technical Note 123

Naval Ocean Research
and Development Activity
NSTL Station, Mississippi 39529

Report of FY81 Effort for PIFS-N Model

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December 1981

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Executive Summary

The PIFS-N model was modified to run in an operational format at FNOC. Changes were made in the model structure to allow easy interface with the FNOC operational data bases and CY203. Because of the new CY203, many aspects of the operational use of the machine were not yet decided or made public. In these cases a system was set up to simulate the operational interfaces of the PIFS-N model.

A more complete heat budget was added to the model and used for calculating the growth rates of thin and thick ice.

A long term simulation was attempted on the CY203. Several problems, associated with the initializing data, were detected and the run was stopped after two years of model time were simulated. Investigation into the initializing data showed inaccuracies in the surface wind data. Methods were outlined to solve these problems.

Problems which would affect the model performance upon grid expansion were also identified with methods of solution.

1.0 Introduction

Present operational Arctic sea ice forecasts are produced at Fleet Numerical Oceanography Center (FNOC) using an empirical model of interaction between the ocean surface, sea ice and surface winds. This model, named the SKILES model, is run over the Northern hemisphere from 45N to the pole. Ice drift forecasts are made at all grid points within this region defined as being on the FNOC hemispheric grid. Forecasts of ice movement are made, whether ice is present or not. Forecast results are interpreted as the direction and speed of ice drift, provided ice is present at an individual grid point.

Numerous deficiencies have been known to exist within the SKILES model used at FNOC. The model does not consider the thickness concentration or growth of the ice pack. Within the ice covered Arctic Ocean, the freezing of the water in a particular area is dependent upon the thickness of ice already in the area plus the amount of open water in the area. These parameters vary with and are dependent upon the transport of the ice pack. The model developed by Dr. W. D. Hibler, III, at the U. S. Army Cold Regions Research and Engineering Laboratory has coupled these dependencies by allowing ice interaction to depend upon ice thickness and opening in the ice pack (Hibler, 1979; 1980).

An assessment of operational requirements of the U. S. Navy, regarding Arctic sea ice forecasting has been conducted. This led to the recommendation of replacing the SKILES model with an ice forecasting system to include an Arctic basin model plus regional models. These models will include thermodynamics and drift. The Hibler sea ice model has been designed for use in seasonal simulation over the Arctic Basin. This model represents the present state of the art and thus was chosen for use as the Arctic basin model.

The Arctic Ice Dynamics Joint Experiment (AIDJEX) produced a sea ice model which was primarily designed for regional simulation of sea ice behavior. The AIDJEX model is being considered as the basis to provide regional forecasts of Arctic sea ice conditions.

1.1 Objectives

The primary objectives for FY 81 have been to prepare the Hibler model (hereafter labelled the Polar Ice Forecast Subsystem, North, PIFS-N) for operational use at FNOC. Specific tasks were directed toward making the model function in the operational environment.

Specific tasks for FY 81:

i) Completion of a graphics package for display of all forecast parameters;

ii) Incorporation of a more complete thermodynamic section for calculation of growth rates;

iii) Modifications to enable the model to operate on the CY203 at FNOC;

iv) Perform a long term integration utilyzing FNOC environmental data;

v) Evaluate the results of the long term simulation using statistical techniques.

vi) Prepare necessary documentation in the form of a Functional Description, Users Manual, Computer Operations Manual and Program Maintenance Manual.

The progress made on each task is detailed in the remaining sections of this report.

2.0 Project tasks

A total of 6 tasks were defined to prepare the PIFS-N model for operational use at FNOC. Progress made on each of these tasks is detailed below.

2.1 Graphical Depiction of Forecast Results

FNOC maintains a VARIAN plotter for graphical depiction of operational forecast fields. FNOC also maintains a standardized software package, VARIMAP, which provides the interface between jobs producing forecast products and the VARIAN plotter. The PIFS-N model was altered to use the VARIMAP software for plotting the forecast results.

In general, a job needing to use the VARIAN plot package is required to prepare the data for plotting and use by the VARIMAP software. This involves placing the data on a Random Access disk file through the ZRANDIO software package at FNOC. The ZRANDIO software provides the interface between the data used by an operational job and the storage of the data on the FNOC data base. Therefore, all data files within the FNOC data base are in ZRANDIO format.

An output module was added to the PIFS-N model to create a ZRANDIO disk file which may be used in conjunction with the VARIMAP package. The actual use of the VARIMAP software involves the execution of a separate job after the PIFS-N model is executed. The output module was originally designed on the CDC 6500 at FNOC. At that time, the following variables were processed through the output module;

i) ice drift - packed data containing the i, j grid points, ice drift direction and ice drift speed in one word per grid point;

ii) ice thickness;

iii) ice concentration.

Sample runs were made, during 1980, using this output module on the CDC 6500.

After the module was placed on the CY203 (detailed in section 2.3), many modifications were made to the output module. As described above, the ZRANDIO software package is used to create environmental data files on the CDC 6500 (HAL) (also the PEPS machines and CY175 (SPC)). However, the CY203 uses the CRANDIO software package, designed to be analoguous to ZRANDIO on the scalar machines. Changes were made to the output module enabling the creation of a CRANDIO file rather than ZRANDIO file. These changes involved modifications on the formation of record labels for individual forecast fields plus modifications of the length of each output record. Also more variables were processed through the output module. This was made possible by the incorporation of a heat budget calculation for ice growth rates. The following variables were added to the output module processing;

i) ice strength; (actually model ice pressure)

ii) ice growth;

iii) open water growth;

iv) ice divergence.

The graphic capabilities of the PIFS-N system were completed with the incorporation of the transfer of CRANDIO files on the CY203 to ZRANDIO files on the CY 170/720 (DLA) and CY 175 (SPC) for the actual plotting of results. The CY203 and DLA machines do not have direct access to the VARIAN plotter and VARIMAP software. Therefore, forecast fields calculated by the PIFS-N model need to be transferred from the CY203 to DLA and finally to the SPC for final plotting. This involves the

transfer of a CRANDIO file to a ZRANDIO file which is a complicated procedure. A standard software package, developed for FNOC is used to perform this transfer of a CRANDIO file on the CY203 to a ZRANDIO file on DLA. Therefore, a separate job was created to take the file and process it through the field transfer software to DLA. This job is run after execution of the PIFS-N model. The resulting file on DLA is then transferred to the SPC for plotting. This involves the use of another job which is run on DLA.

In summary, the following procedure was set up to produce plots of the PIFS-N results. This procedure is beyond the initial modifications to the output module;

i) Run a field transfer job on the CY203 to transfer PIFS-N fields from CRANDIO format to ZRANDIO format on DLA.

ii) Run a job on DLA to transfer the PIFS-N file to the SPC;

iii) Run a VARIMAP job to produce the actual plots of the PIFS-N fields.

It is obvious that this is a complicated and time consuming procedure for obtaining the resultant fields. In the future when operational models are run on the CY203, this procedure will be handled automatically for operational processing of forecast fields. However, this capability does not exist at the present time and it is necessary to operate in the above manner for the PIFS-N development work.

2.2 Incorporation of the Heat Budget and Use of the CY203

Tasks 2 and 3, as described in Section 1.1, were combined into one task. Due to storage limitations on HAL, the incorporation of the heat budget code was not feasible. Addition of the heat budget requires the use of several FNOC operational data fields. This fact plus the addition of new code resulted in the PIFS-N model being larger then the required 110,000 octal words limit for HAL. Therefore, the heat budget was added concurrently with the placement of the model on the CY203.

The heat budget code was received from Dr. Hibler as it existed in his version of the Dynamic Thermodynamic Model. Virtually no changes were made to the heat budget code. However, a section was added to interface with the FNOC data base enabling receipt of the necessary atmospheric parameters. This modification was incorporated into a subroutine which is used to "drive" the heat budget subroutine.

The incorporation of the heat budget increased the number of fields which are obtained from the FNOC data bse. These field are;

i) A01 - Surface pressure;
ii) A10 - Surface air temperature;
iii) A11 - Incoming solar radiation;
iv) A12 - Surface vapor pressure;
v) A16 - Sensible vapor pressure;
vi) A18 - Total heat flux;
vii) A20 - u component of the surface wind;
viii) A21 - v component of the surface wind.

The first 6 fields, listed above, are used in the heat budget calculations.

The placement of the model onto the CY203 required that the input and output modules of the model be totally rewritten. The input module was rewritten to access CRANDIO data records containing the required atmospheric data from the FNOC data base. As described above, in relation to the plot processing, ZRANDIO records are transferred from DLA to the CY203 as CRANDIO records which are read by the input module of the PIFS-N model. The input module was re-designed to interface with this new software package rather than the ZRANDIO softwre.

The output module was also re-designed to interface with the CRANDIO software plus produce a hard copy printout of specified forecast fields. Representative runs, on HAL, during 1980, produced hard copy printouts of ice drift, thickness and concentration in tabular format with grid point values identified by their respective latitude/longitude values.

This was changed on the CY203 to produce printouts on the actual format of the grid. This makes a visual inspection of the forecast fields possible without producing a plot for indication of the spatial distribution of values.

A section of the output module was modified to provide and maintain a CRANDIO file on the CY203 SEAICE account. This file is used during simulation testing for storing forecasts and providing initialization data for subsequent runs. This file was set up to emulate the FNOC operational data base with which the PIFS-N model will interface in an operational state. All tests of the interface of the PIFS-N model with the data base were successful and it was used in the multi-year simulation discussed in subsequent sections of this report.

No major modifications were necessary to the main computational sections of the PIFS-N model, for placement on the CY203. Only minor syntax type variations plus minor variations in the FORTRAN versions between the two machines caused alterations of the PIFS-N model. However, no serious attempt was made to vectorize the code. This would require numerous modifications to the code structure.

At the completion of these tasks the PIFS-N model was brought up on the CY203 with the completed heat budget code. Test runs were made utilizing the same input data on the CY203 as used on HAL for result comparisons. These tests were made without the heat budget, since it did not exist on the HAL version. Test results indicated that forecast fields were equivalent between runs on the different machines (CY203 and HAL). The heat budget code was tested as a stand along entity using simulated input data and results supplied by Dr. Hibler.

2.3 Longterm Simulation

The test of the PIFS-N model results included a 1 year simulation, using FNOC data, and comparing results with 1979 FGGE buoy data of ice drift. To achieve a one year simulation the model needed to be run for a total of 5 years. Four years would be used as a "spin up" simulation with the fifth simulation year being taken as the actual forecast test year. The year 1979 was chosen because of the availability of FGGE buoy data. The ice drift fields interpolated from the buoys to a lat/long grid were obtained for comparison with the PIFS-N model output.

The necessary atmospheric data fields for 1979 were obtained from the FNOC climatology data base. The required 8 input fields were obtained for each day of 1979. The data was then grouped into 8 day averages for use in the PIFS-N simulation.

The 8 day averages were constructed with overlapping 4 days. For example, the month of January was averaged as follows;

JAN   Group 1   Group 3
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
                        Group 2

and so on, throughout the year.

During the model simulation atmospheric data was changed every fourth day of the simulation. For example, a simulation beginning in January, as shown above, the first data group will be an average of days January 1 through 8. This data will be used for simulation days January 1 through 4. On January 5 the input data is altered to be the average of January 5 through 12. This data is used through January 8 where the data averaged over January 9 through 16 are brought in. This process is used for the entire year. This technique was chosen based on sensitivity experiments and recommendations of Dr. Hibler (Hibler, 1979). The overlapping 4 days provided a smooth transition between data regimes (8 day groups).

The data analysis described above was completed on DLA while the files were in ZRANDIO format. The finalized data set was transferred to the CY203 and CRANDIO format for the required simulation. The actual simulation was run 1 month at a time on the CY203. The CRANDIO data base, described in Section 2.2, was used to store forecast files for the initialization of each subsequent month.

The simulation was started and run for a period of 2 model years. At that time, inspection of the results indicated several problems were occurring within the run. These problems are detailed in Section 3. Because of these problems the simulation was stopped midway through the third year. Resultant plots for each month of the second simulation year are presented in Appendix A. The forecasts of ice thickness drift, concentration, and growth are presented. Also representative plots of the monthly averaged wind data are shown. This is the wind data which was used in the simulation. The ocean curent data is also presented as used by the PIFS-N model and as it appeared in the SKILES model. The data was interpolated from the FNOC hemispheric grid to the PIFS-N grid. The ocean current data does not change throughout the simulation.

2.4 Statistical Evaluation

Statistical evaluation of the PIFS-N simulation results was not performed. It was decided that because of the problems encountered during the simulation run, a statistical evaluation would be fruitless. Discussions lead to the conclusion that statistical analyses would best be utilized after the known problems incurred during the PIFS-N test are solved.

One suggested approach to the evaluation of the ice drift forecasts is to use a contingency table technique.

2.5 Documentation

The following manuals were prepared for PIFS-N:

i) Functional Description;
ii) Program Maintenance Manual;
iii) Computer Operations Manual;
iv) Users Manual.

The manuals were written to describe the operation and maintenance of the PIFS-N system. Specific details in the interface of the PIFS-N and the operational stream on the CY203 were not included because the specifics of the operational use and transfer of files between the CY203 and other machines have not been finalized by FNOC.

2.6 Summary of Progress on FY 81 Tasks

During 1981 five of the six tasks were completed in terms of bringing the PIFS-N model to operational status at FNOC. These tasks are summarized below:

i) A graphical display interface was set up between the PIFS-N model and the FNOC system.

ii) A heat budget was added to make the thermodynamic section of the model complete.

iii) The model was brought up on the CY203 at FNOC.

iv) A test simulation was run in which problems were found that profoundly influenced the simulation results. The problems discovered must be solved before further testing can be accomplished.

v) Statistical evaluation of a simulation was not performed.

vi) Documentation, in the form of a Functional Description, Maintenance Manual, Users Manual, and Operations Manual were completed.

3.0 Long Term Simulation Problems

The PIFS-N model was run for a 2 year simulation on the CY203 at FNOC. The original plan had called for a five year simulation upon which numerous statistical evaluation procedures would have been carried out. During the execution of the planned 5 year run, numerous problems became evident causing a decision to be made to stop the simulation at the 2 year mark. This section documents the problems incurred during the 2 year simulation including the probable cause and possible solution.

The main problems detected during the simulation were the input surface wind components and the input ocean surface current. A less severe problem involving the appearance of the contout plots was also detected. The technique used to run the model for the 2 year time frame is outlined in Section 2.3. One day time steps were used for this test.

3.1 Input Surface Wind Data

The u, v surface wind components are used by the PIFS-N model for calculation of the air stress through the use of a square drag law. The dominance of the air stress over the ocean stress upon the ice varies depending upon the length of the simulation. For short term simulations, the air stress is dominant over the ocean stress but in simulations over the annual cycle the ocean stress term becomes more important (Hibler, 1979). Because the PIFS-N model will primarily be used as a forecasting model in the operational sense (short term simulations) the air stress calculations become very important. Therefore, the accuracy of the wind data used in the calculation of the air stress is extremely important.

Inspection of the ice drift patterns in Appendix A illustrate several "trouble" areas. For example, examine the mean January ice drift pattern. Note the line of convergence paralleling the north coast of Greenland extending from the grid edge to the pole area. Another feature, apparent on the January and February ice drift plots is the convergence of ice drift vectors at the north pole. This feature is evident in several monthly ice drift patterns. Observations of these drift vector patterns caused the investigations of the quality of wind data input.

Appendix A presents the monthly averaged wind data for a sample of months throughout the year. These wind data are obtained from a Planetary Boundary layer (PBL) model run

operationally at FNOC. These winds are not geostrophic. They are calculated using a boundary layer parameterization designed for the mid latitude oceans.

The average January wind data in Appendix A will be used as an example. The wind vectors are spinning into the pole point. This type of wind pattern is indicative of a "theoretical" low pressure over the area. However, this is a very unrealistic surface wind pattern. This type of wind is probably due to the incorrect parameterization (coriolos force and mixing length) for the calculation of wind in the polar region. An inspection of the average wind data for February illustrates the opposite type of pattern. In this case winds are diverging away from the pole point, indicative of a theoretical high over the area. Again this is a very unrealistic pattern. These wind patterns are responsible for the unrealistic ice drift vectors near the pole point.

The unrealistic wind vector problem is enhanced by the fact that these winds are not geostrophic winds as input. The calculation of the air stress, as it exists in the model, incorporates a turning angle into the wind data. The incorporation of the turning angle into the non-geostrophic wind compounds the inaccuracies in the wind data. The problems of the wind data illustrated above are common to most months of the year.

Approximately 400 seconds were required on the CY203 to run the model for one month during this simulation. However, the simulation for the month of March required an average of 1500 seconds to run. The ice drift plot for the month of March shows a more disorganized pattern than other months. The atmospheric wind data for March illustrates a "unique" wind pattern. Wind vectors are diverging away from the pole point and converging to a point near 125W, 80N. This probably reflects the combination of high and low pressure systems subsequently an increased

processing time for the March simulations. The increased amount of time is taken up in the relaxation technique of solving the momentum equation, caused by the complex wind pattern. There appears to be a direct connection between the operation of the PIFS-N model and the validity of the wind data.

It is obvious that the quality of the wind data must be improved to produce acceptable forecasts with the PIFS-N model. There are a number of procedures which would provide more reasonable wind data. The most elaborate procedure would involve the incorporation of an atmospheric boundary layer module within the PIFS-N model. This would provide the most accurate wind data. However, this would involve many modifications to the existing PIFS-N model.

A recommended course of action is to use the sea level pressure fields produced at FNOC, to calculate the geostrophic winds. This would require only minimum modifications to the PIFS-N model in its present form. Furthermore, the pressure fields at FNOC can quickly be compared with the observed values provided by the buoy data gathered during 1979. This would provide an immediate check as to whether this method will solve the wind data problem.

3.2 Ocean Currents

The ocean currents at the surface, which were used in the PIFS-N model run are shown in Appendix B. The ocean current values do not change from month to month, therefore, these data are used throughout the entire smulation. The current directions tend to be qualitatively good near Alaska and the Canadian Archipelago, however, the quality is poor near the pole and extending eastward. The low quality data in this region coincides with the lines of converging ice drift vectors extending from the pole eastward.

The ocean current data were taken directly from the SKILES ice drift model at FNOC. The data were originally on the FNOC 63 X 63 hemispheric grid and were interpolated to the model grid. The SKILES data is shown, on the hemispheric grid in Appendix B.

The interpolation of vector data from a coarse grid to a find grid can cause problems. The problem exists in the procedure used here, in dealing with the ocean currents, plus in the interpolation of wind data from the FNOC grid to the model grid. It is possible for discrepancies, within the original current data to be magnified by the interpolation process. An example of this is shown by the value of 18 cm/sec assigned to the current vector of the SKILES data near 74N, 135W. This is a very large value, compared to those surrounding it. This large value was transmitted to a number of points in the interpolated model grid.

The only possible solution to the poor ocean current data is to obtain different sets of data. A number of sources need to be contacted in hopes of obtaining more valid data. This includes the possibility of obtaining the data used by Dr. Hibler or different data available at FNOC.

3.3 Contour Plots

The contour plotting package, available at FNOC for use with the VARIAN plotter is mainly designed for contouring data fields on the FNOC 63 X 63 hemispheric grid. Although a "zoom" capability exists, the software still assumes that the hemispheric grid is filled with data. In the PIFS-N, only a small portion of the hemispheric grid contains data. If the plotting software package with only a small portion of data is used; contours will reflect the lack of data by anomalous

gradients on the edges of the area. Figure 1 shows a contour plot where the edges were contoured incorrectly due to a lack of data around the polar region. This problem was quickly solved by spreading the PIFS-N forecast values out over the hemispheric grid in order to provide a more precise ice edge contour. An ice edge countour, available from climatology is produced at FNOC. However, this capability would not be useful with PIFS-N as configured. The most precise depiction of the ice edge and ice concentration will be through the plotting of grid cell concentration values in cells where the ice edge is defined. This would produce a plot with a line of points and concentration values ($\leq$ 0.2) which will define the ice edge.

3.4 Grid Expansion Problems

Until this point all discussion has been concerned with the operation of the PIFS-N model over the Arctic basin. However, in final form the model is expected to run over the northern hemisphere from the pole to 45N. This expansion presents some new problems which must be solved.

The main problem is the incorporation of a more complicated set of ocean currents and warm water intrusion into the ice pack. The ocean current and thermal structure becomes much more complex and needs to be handled with better initialization data than currently available. Dr. Hibler is currently developing a version of his model which will run over an area east of Greenland. His work should aid in the solution of the warm water intrusion problem as it pertains to the PIFS-N model.

The other major problem is the incorporation of a much more complex boundary when the model is expanded. This will

significantly affect run time and model performance. The incorporation of the irregular boundary could only be attempted after the PIFS-N model was sufficiently optimized on the CY203.

The solution is not to expand this model but to substitute regional models for the specified ocean areas down to 45°N.

3.5 Summary of Problems

In summary, several problems were incurred during the running of the PIFS-N model. The most severe of these problems concern the initializing data. The problems are listed below in order of importance:

i) Initial wind data has been shown to be inaccurate;
SOLUTION: Calculate geostrophic winds from the FNOC sea level pressure fields.

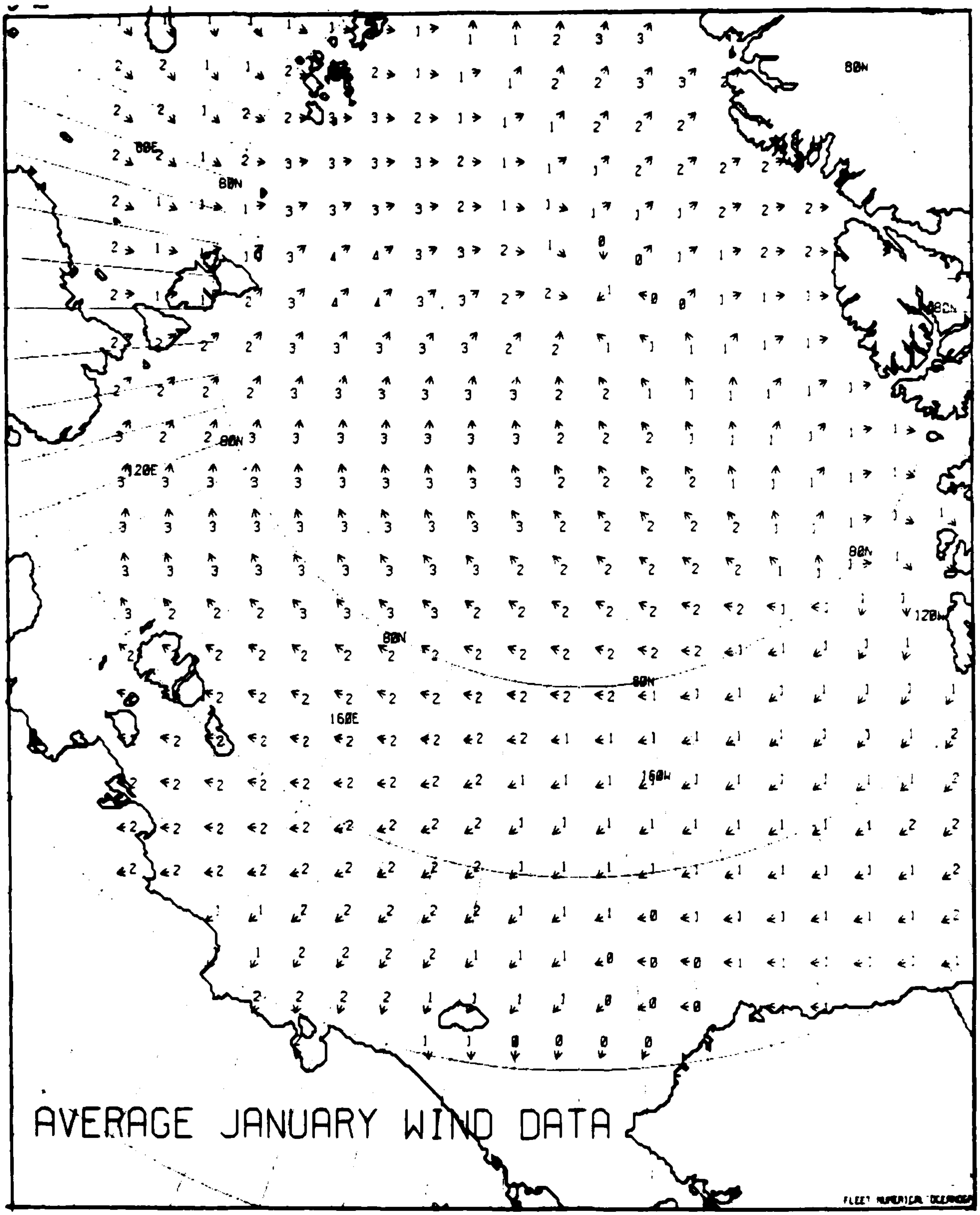
ii) The ocean current data has been shown to be inaccurate:
SOLUTION. Obtain a new ocean current data set.

iii) Upon grid expansion the ocean current and thermal structure is much more complex and needs to be treated differently than currently being done:
SOLUTION: Restrict this model to the Arctic Basin and use regional models for the ocean areas down to 45°N.

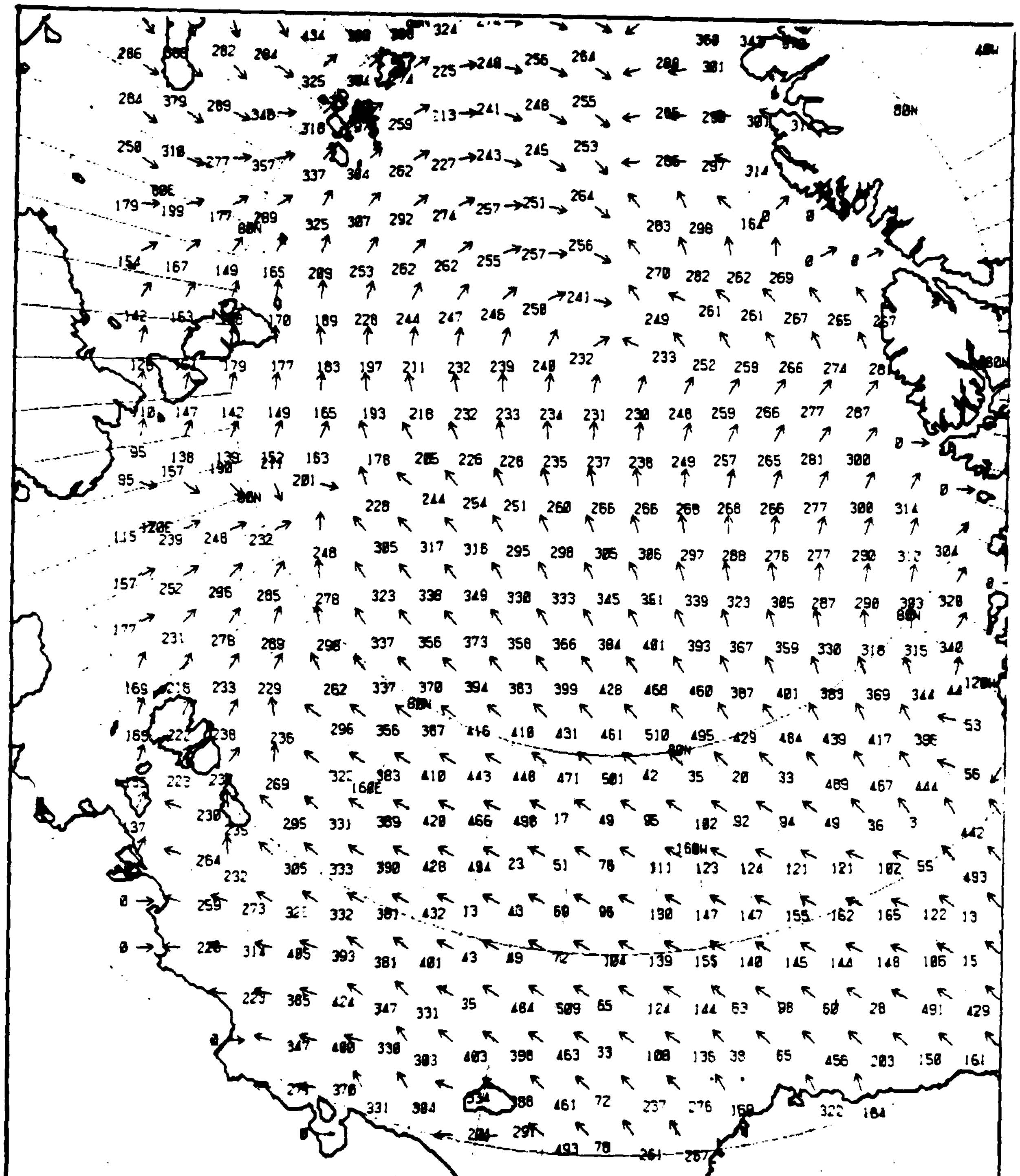
iv) Contour plots of the ice edge are inaccurate:
SOLUTION: Produce grid point plots of ice concentration (≤ 0.2) that define the ice edge.

Appendix A

Plots of Ice Drift, Concentration Ice Thickness, Open Water Growth, Ice Growth and Surface Winds for the Long term Simulation

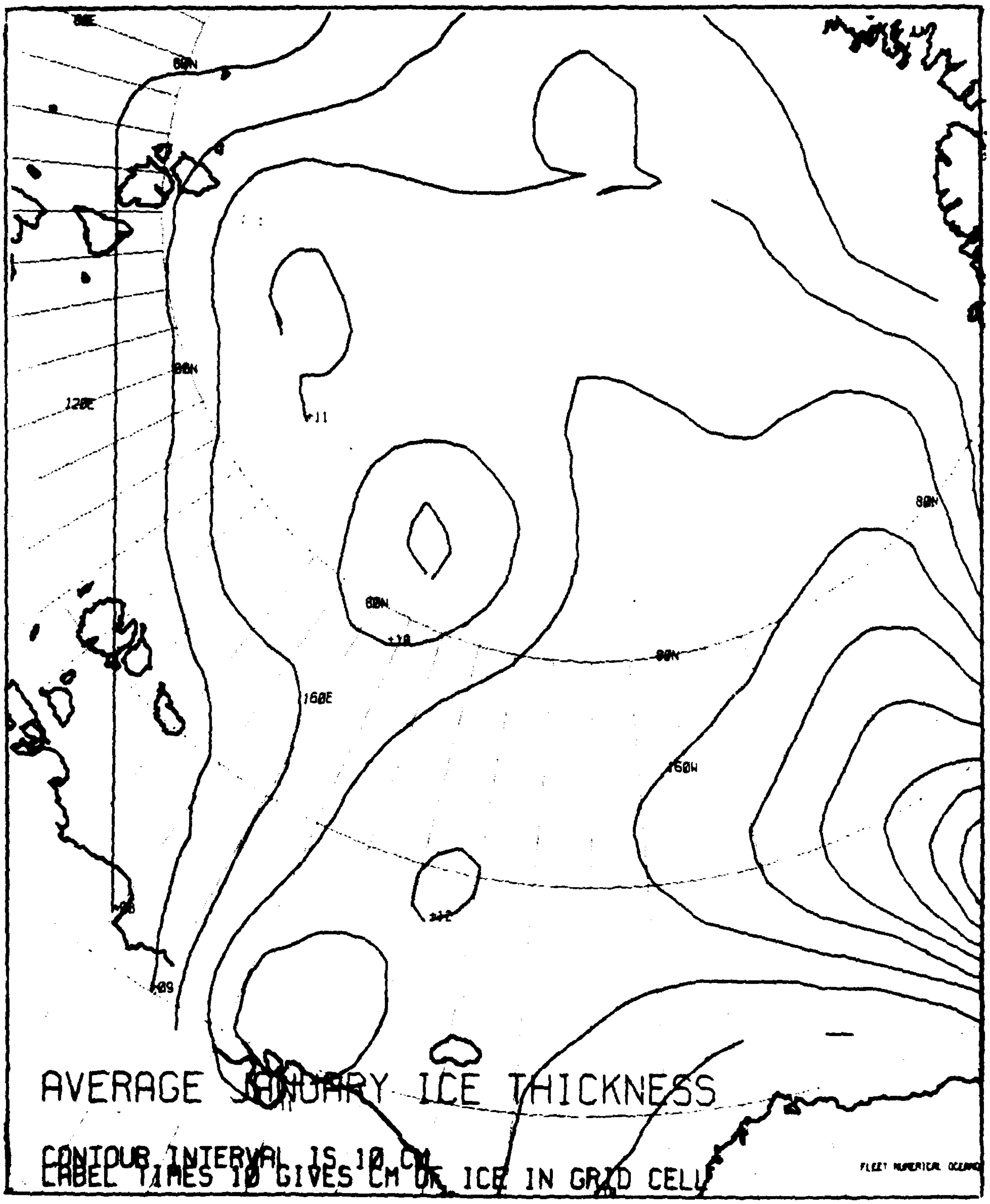


Wind data is in m/sec.

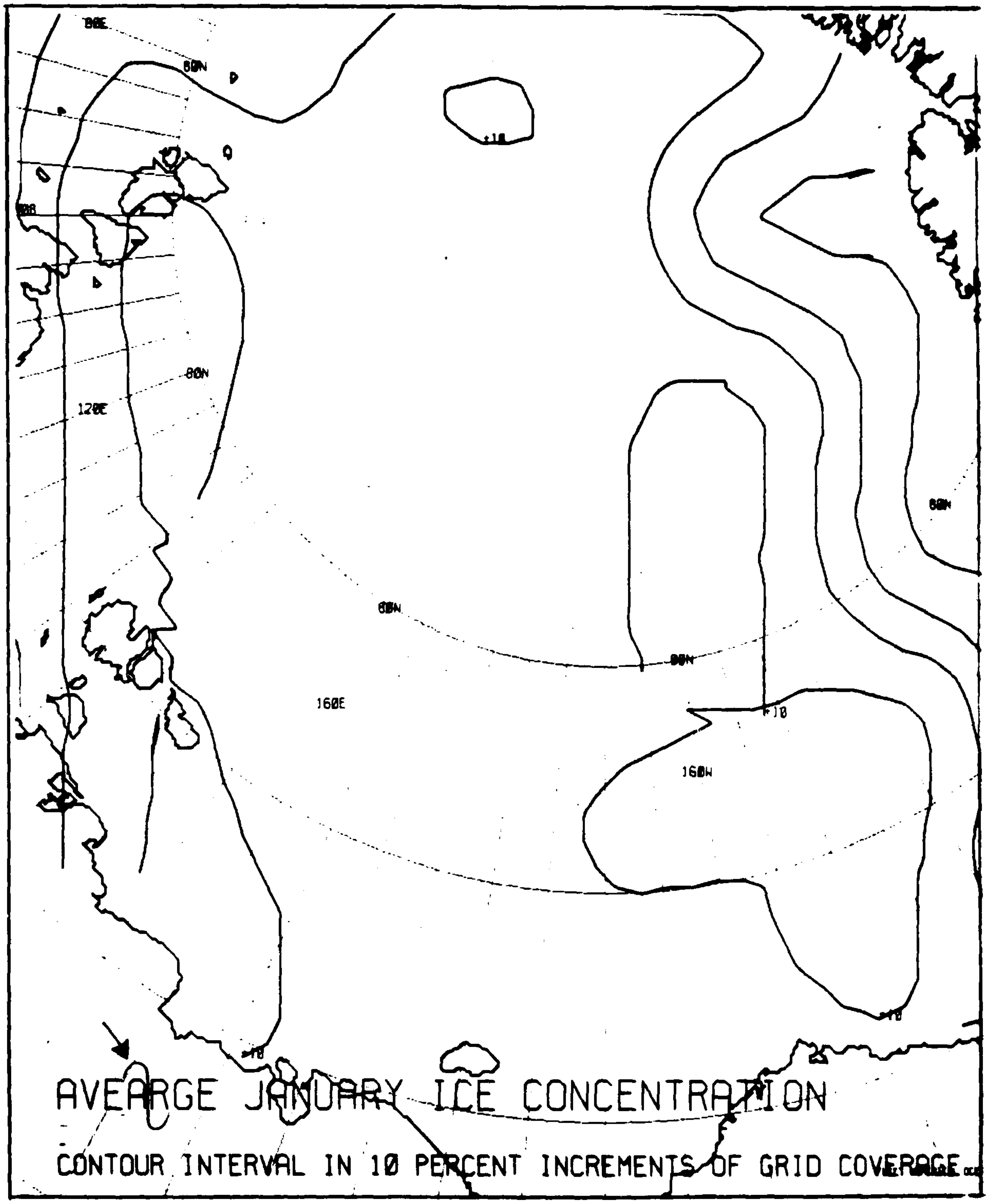


MEAN JANUARY ICE DRIFT

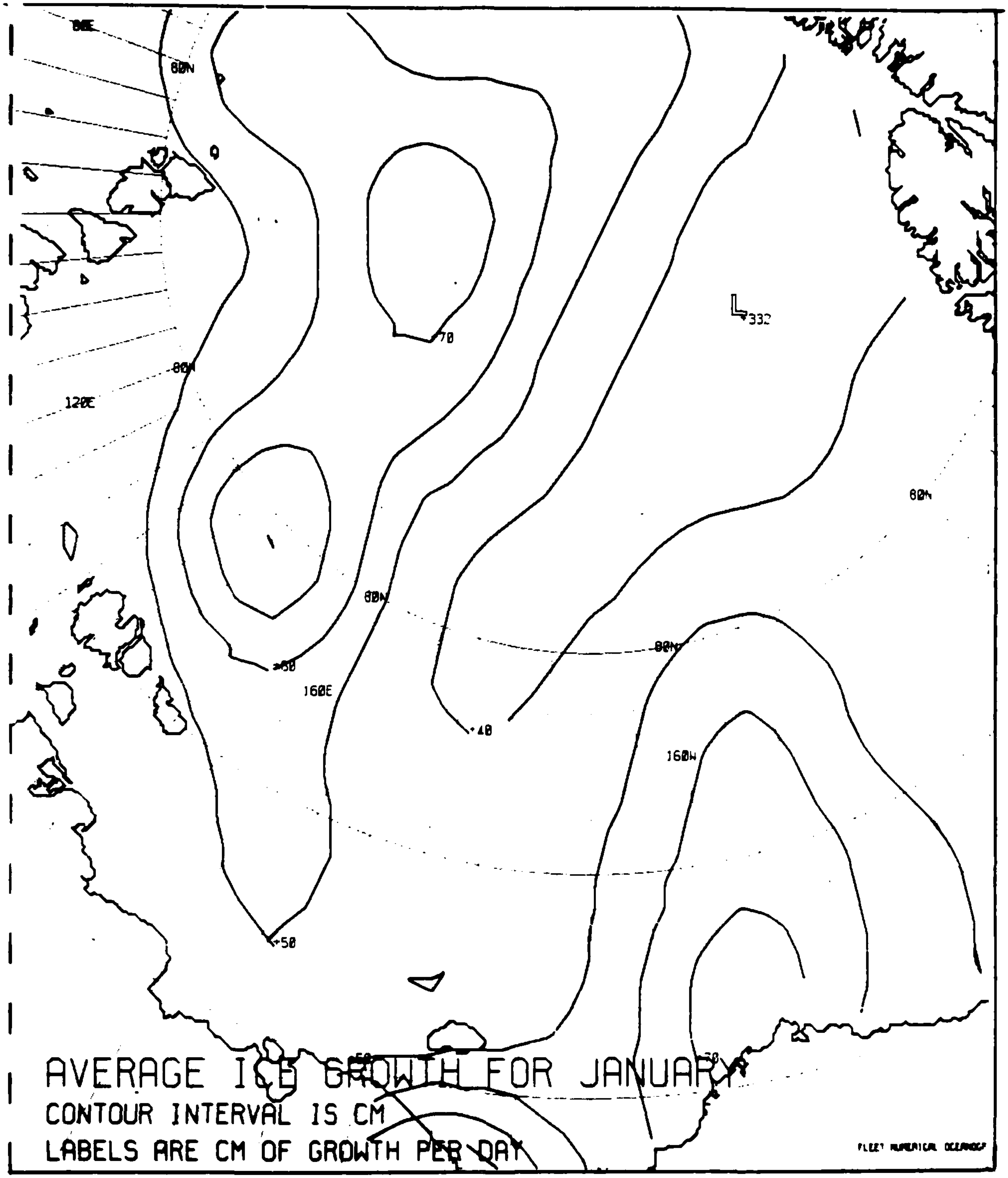
HUNDRETHS OF NAUTICAL MILES OF ICE MOVEMENT IN 24 HRS

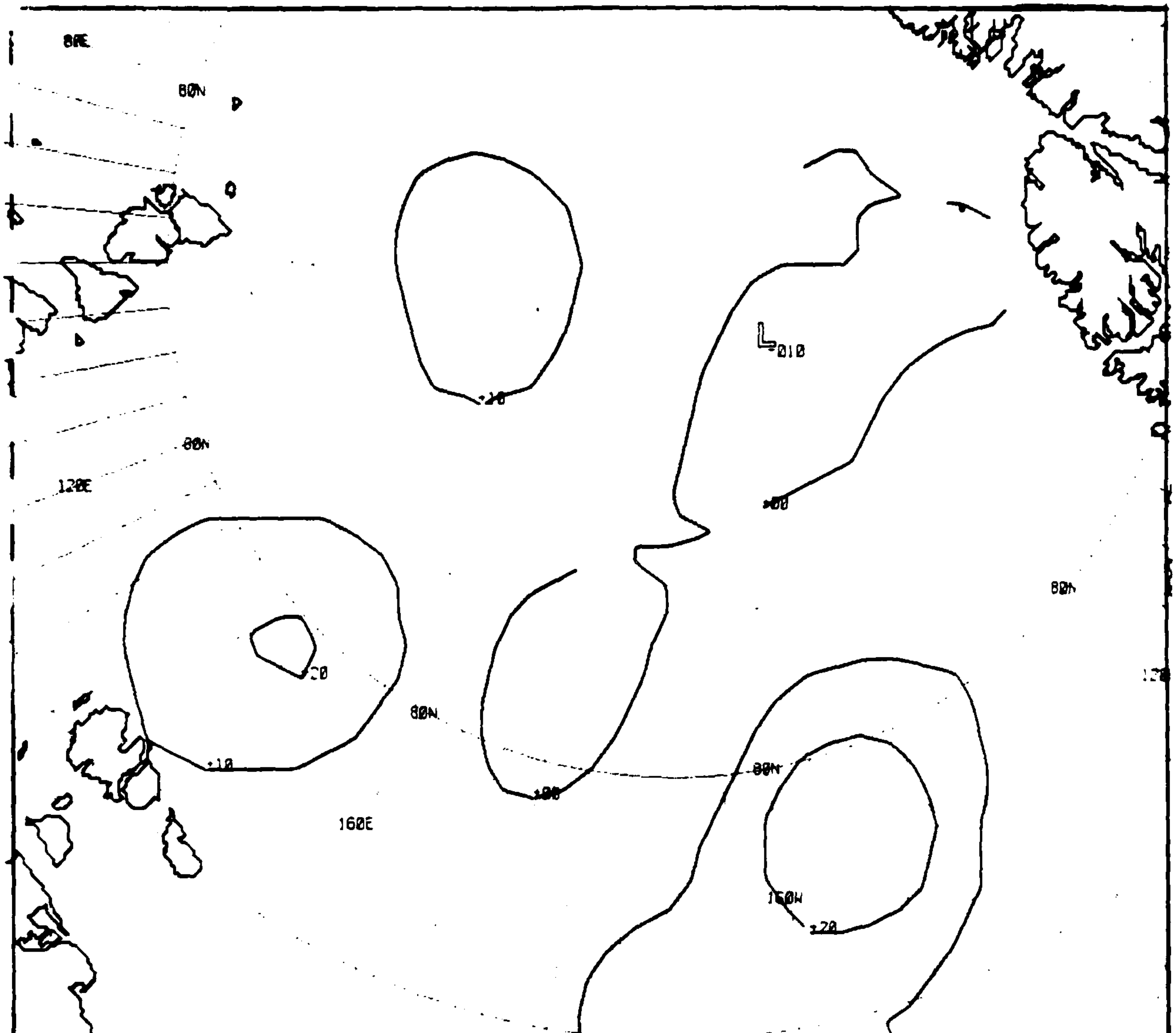


80E
80N
120E
+11
80N
+10
80N
160E
160W
+12
AVERAGE JANUARY ICE THICKNESS
CONTOUR INTERVAL IS 10 CM
LABEL TIMES 10 GIVES CM OF ICE IN GRID CELL
FLEET NUMERICAL OCEANO

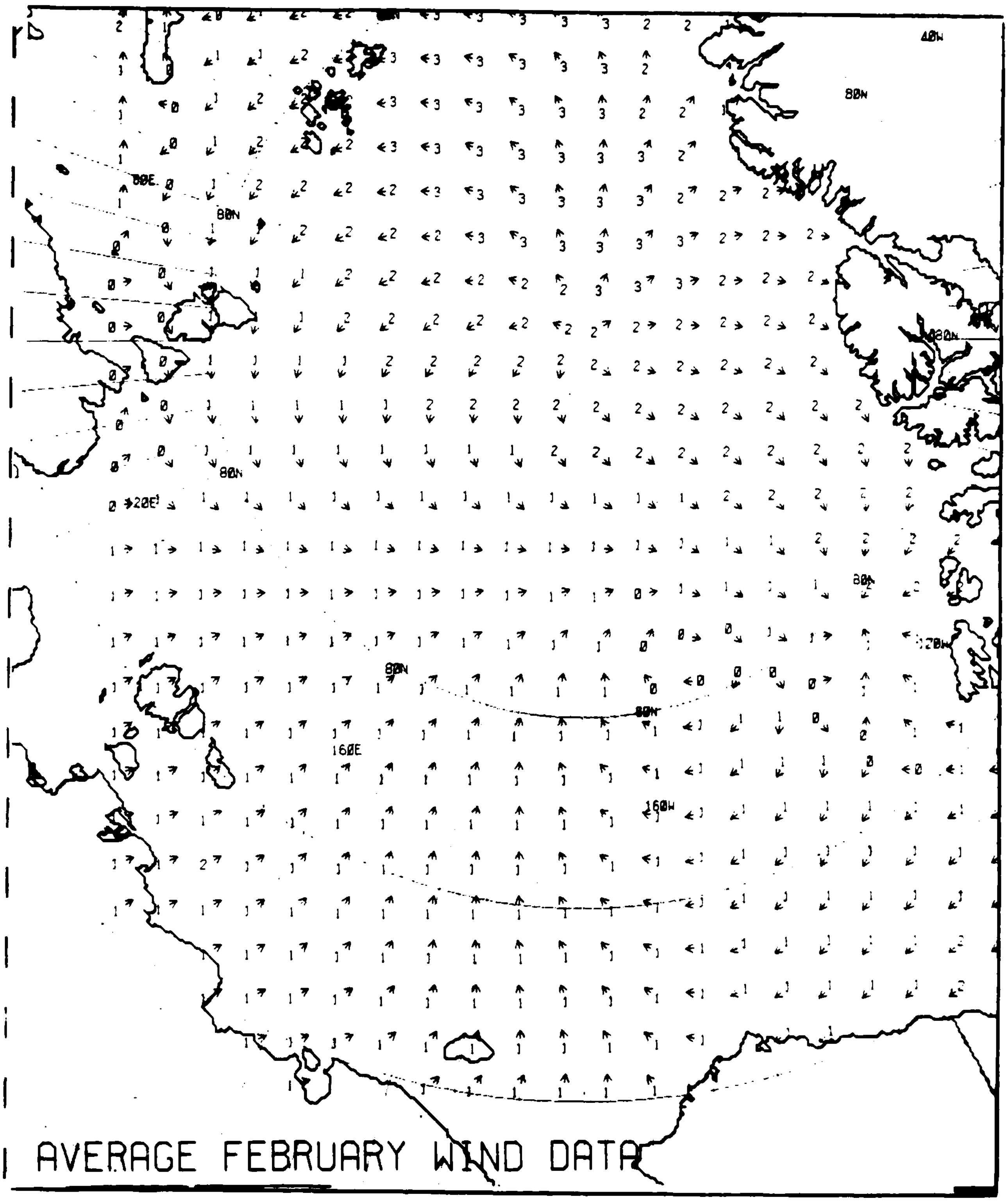


Labels times 10 gives the percentage of the grid cell covered by thick ice.

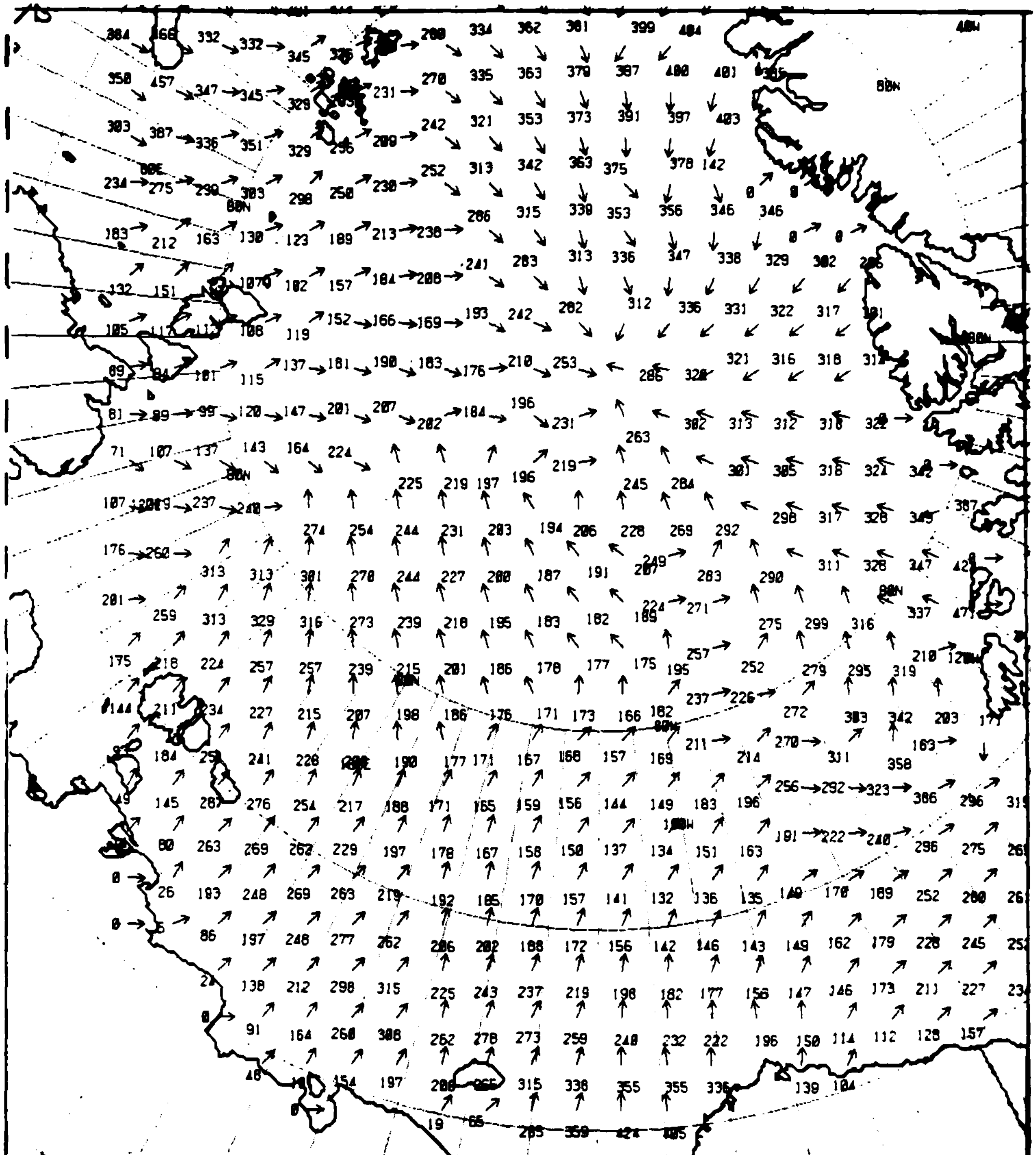

80E
80N
70
332
80N
120E
80N
80N
60
160E
40
80N
160W
50
50
30
AVERAGE ICE GROWTH FOR JANUARY
CONTOUR INTERVAL IS CM
LABELS ARE CM OF GROWTH PER DAY



AVERAGE OPEN WATER GROWTH FOR JANUARY
CONTOUR INTERVAL IS CM
LABELS ARE CM OF GROWTH PER DAY

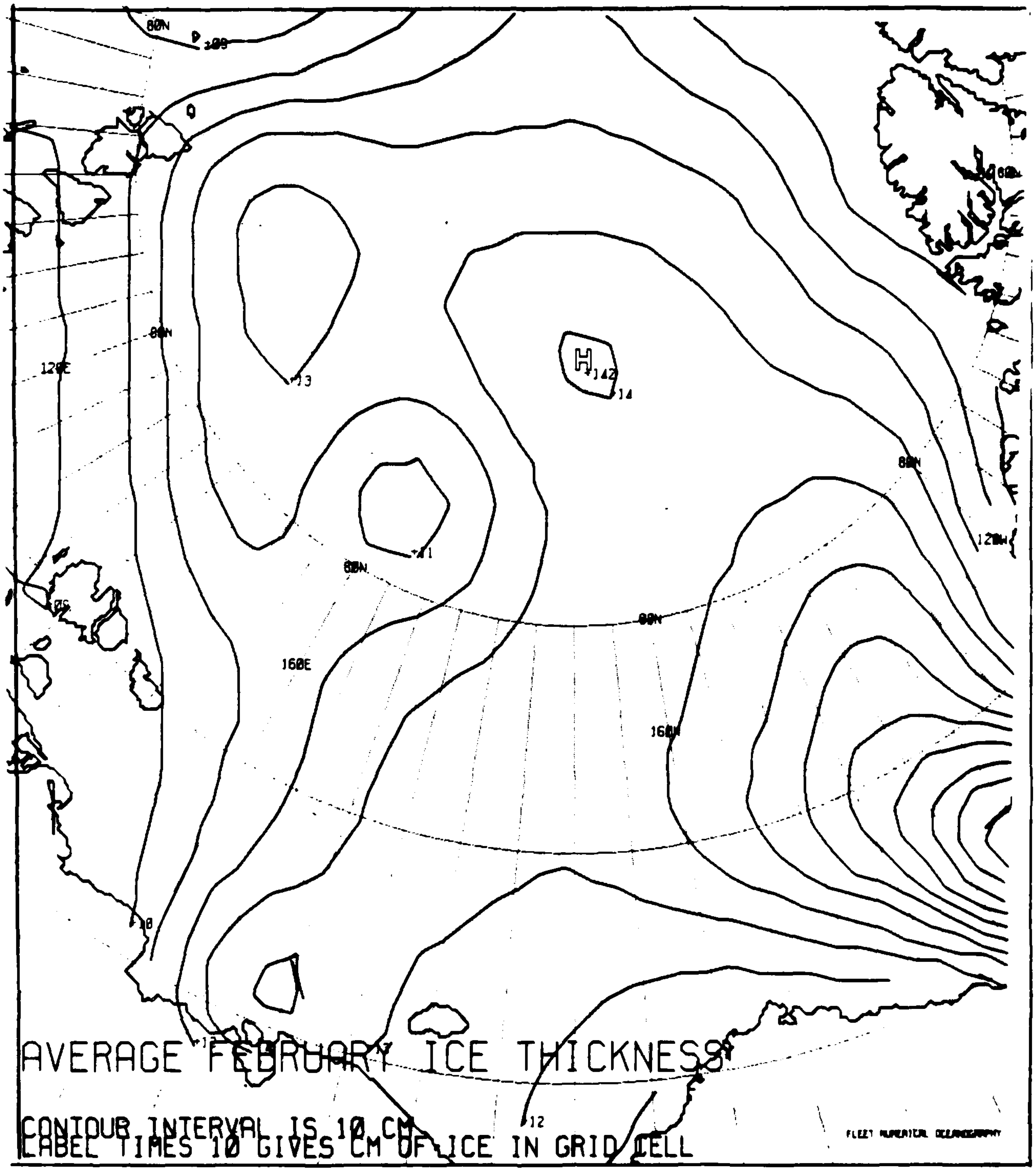


AVERAGE FEBRUARY WIND DATA

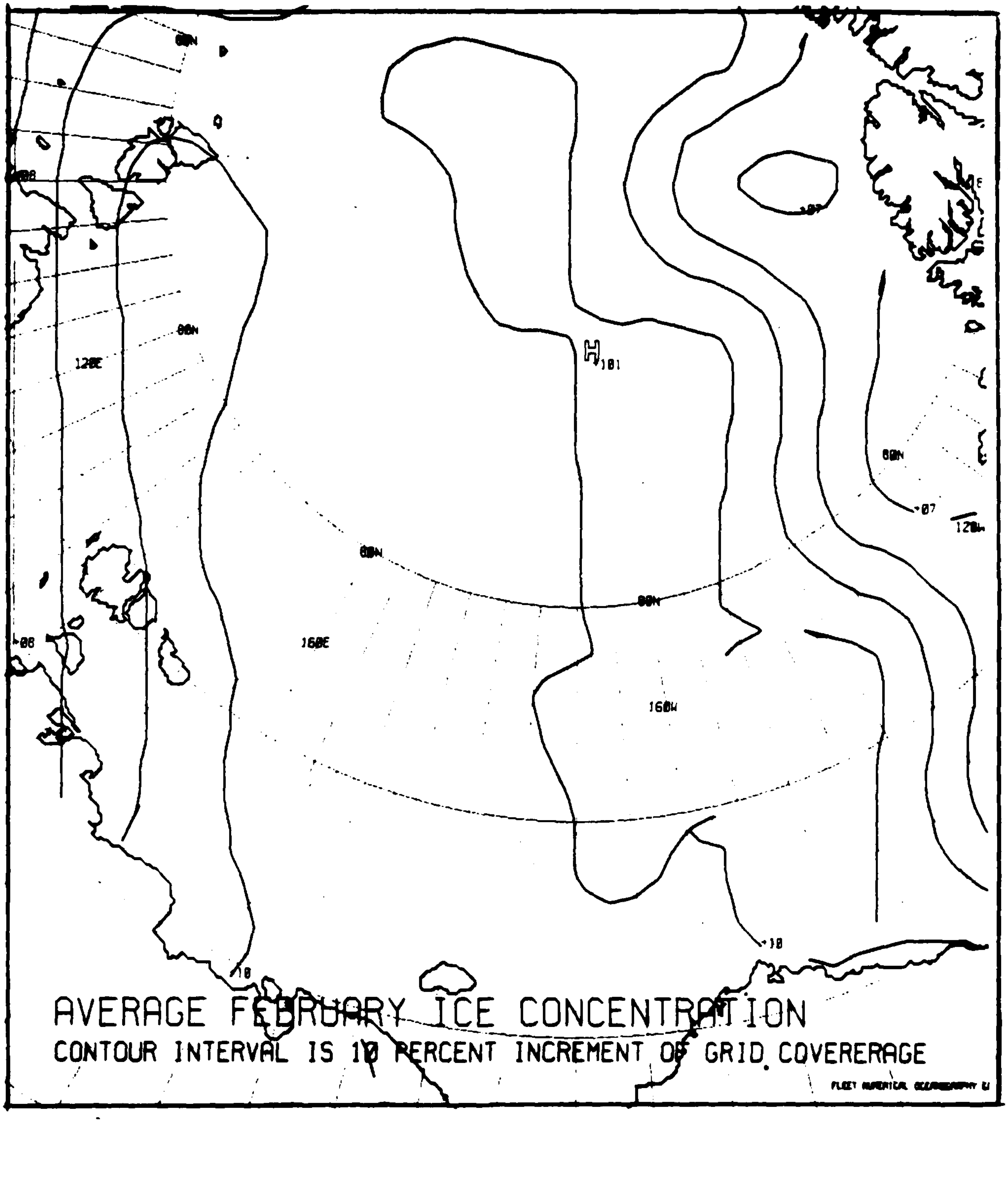


MEAN FEBRUARY ICE DRIFT

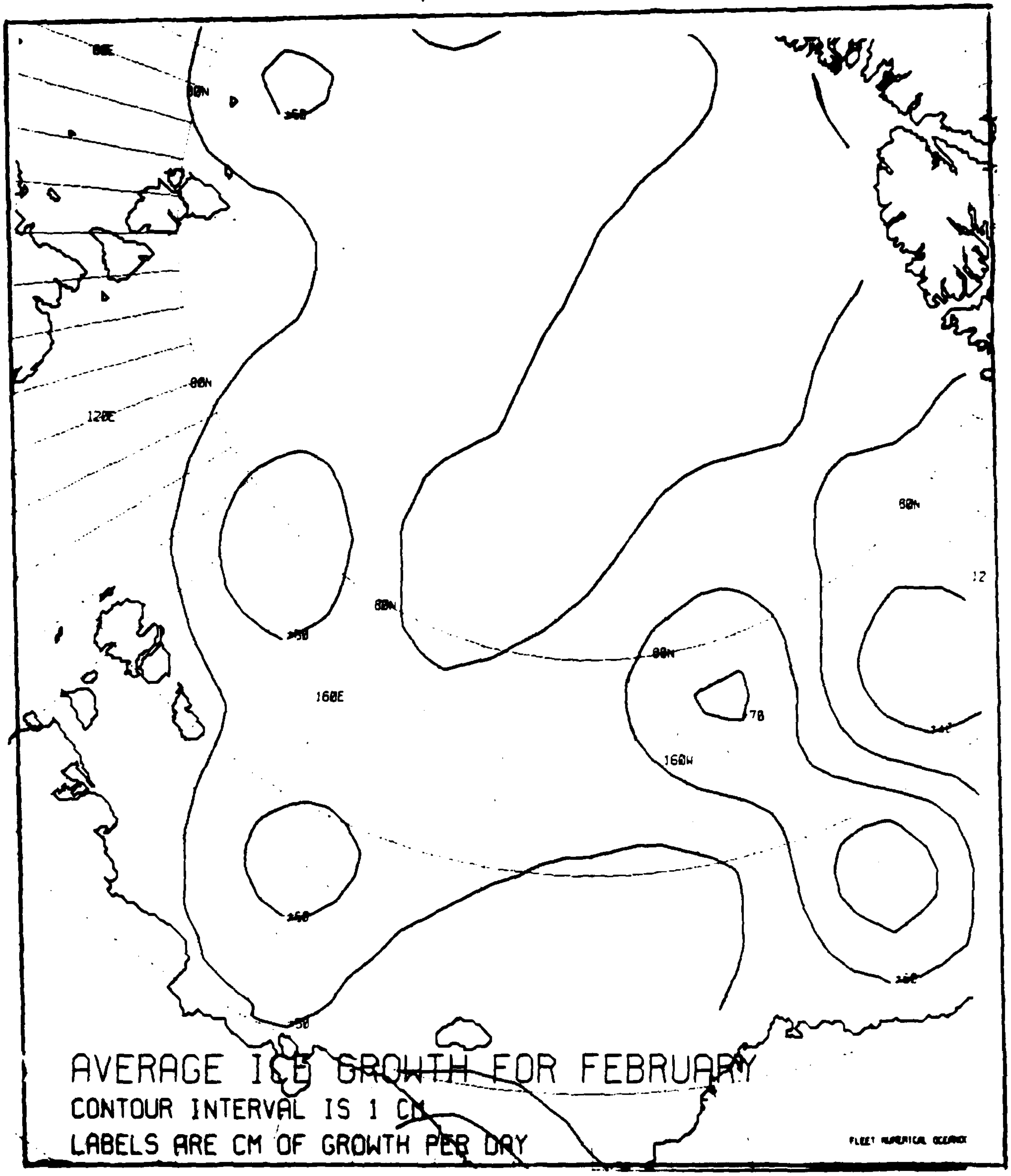
LABEL DIVIDED BY 100 GIVES NM OF ICE MOVEMENT IN 24 HRS



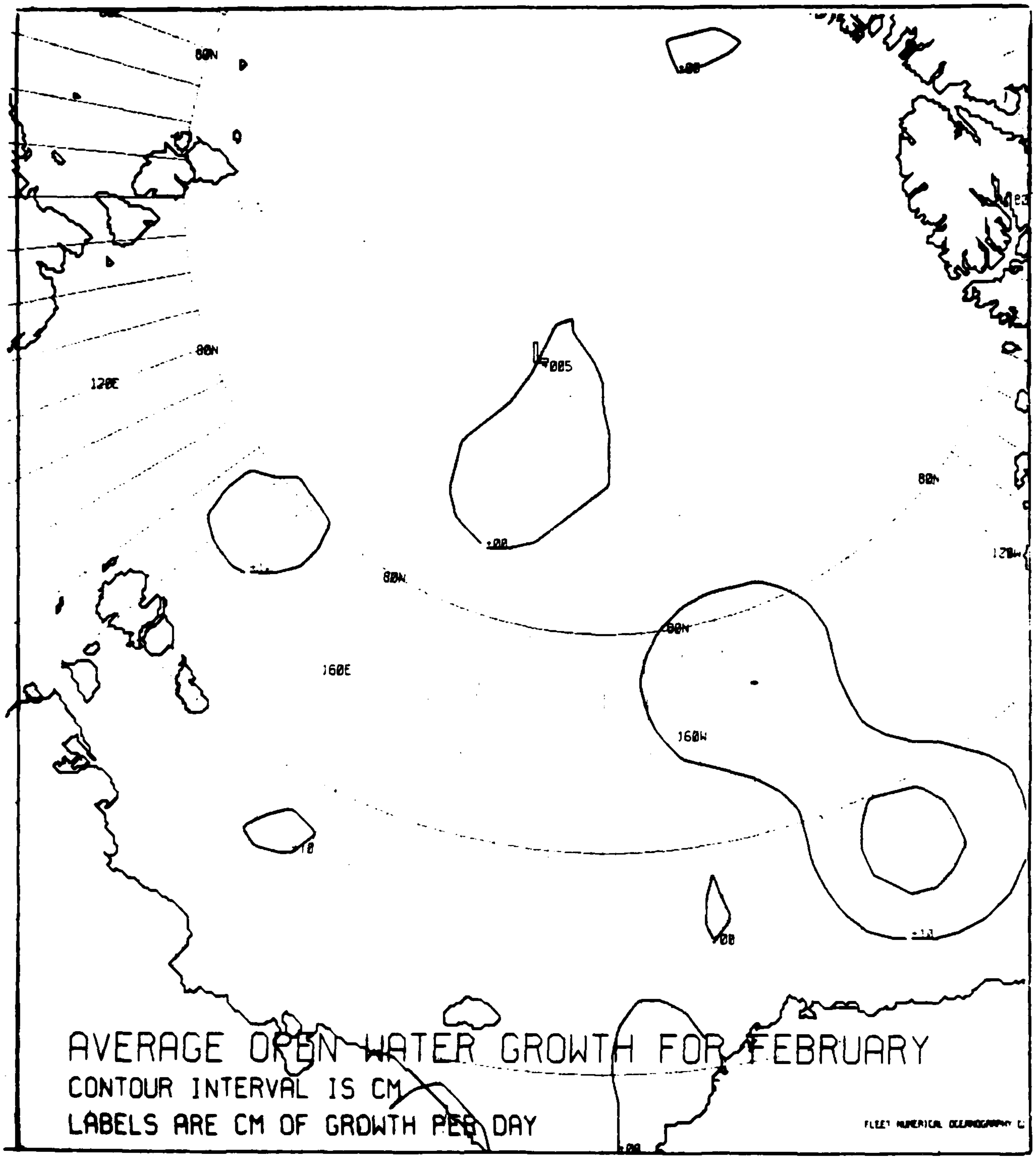
AVERAGE FEBRUARY ICE THICKNESS
CONTOUR INTERVAL IS 10 CM
LABEL TIMES 10 GIVES CM OF ICE IN GRID CELL
FLEET NUMERICAL OCEANOGRAPHY
H
142
14
13
11
12
10
80N
120E
160E
160W
120W

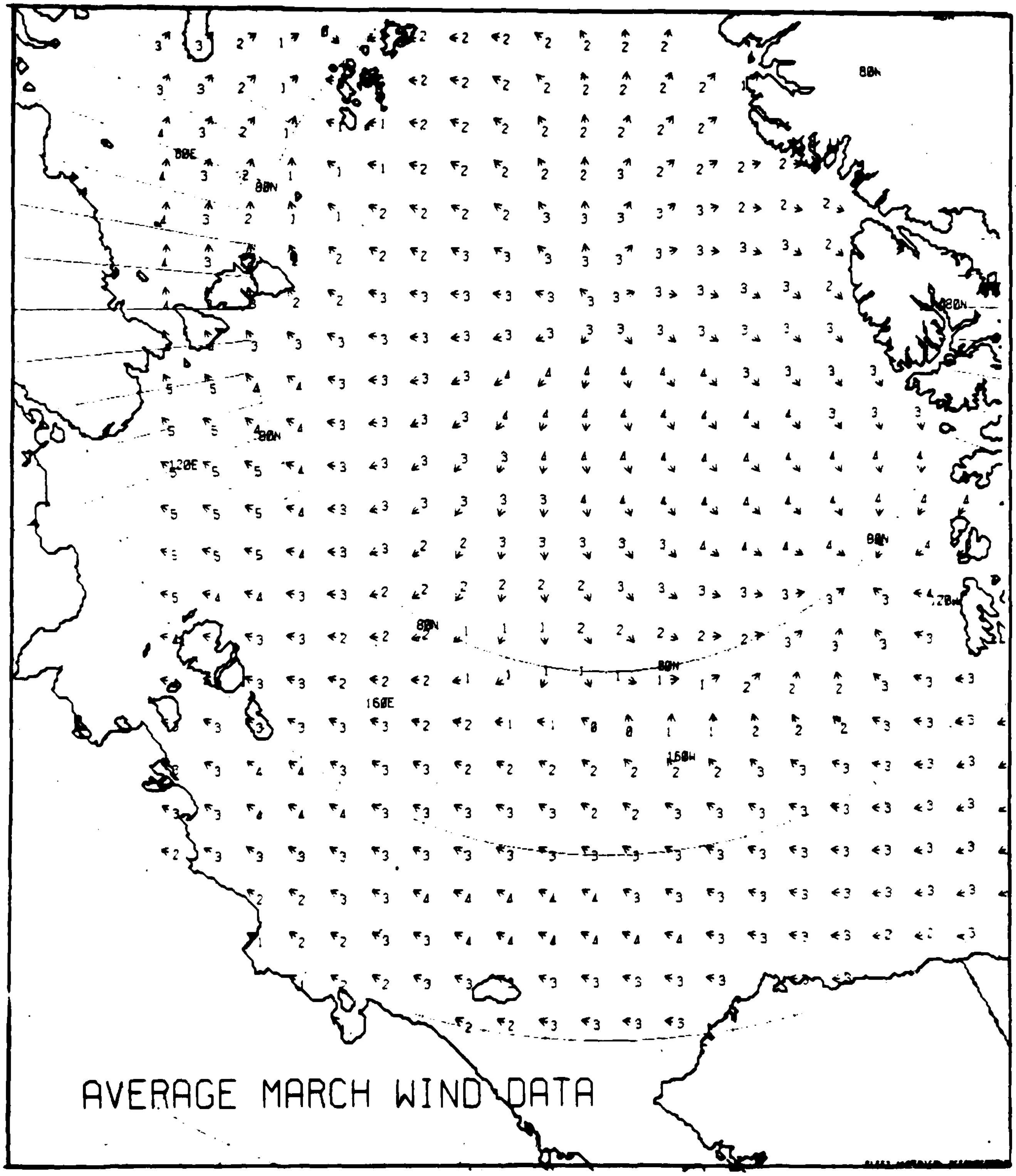


AVERAGE FEBRUARY ICE CONCENTRATION
CONTOUR INTERVAL IS 10 PERCENT INCREMENT OF GRID COVERERAGE

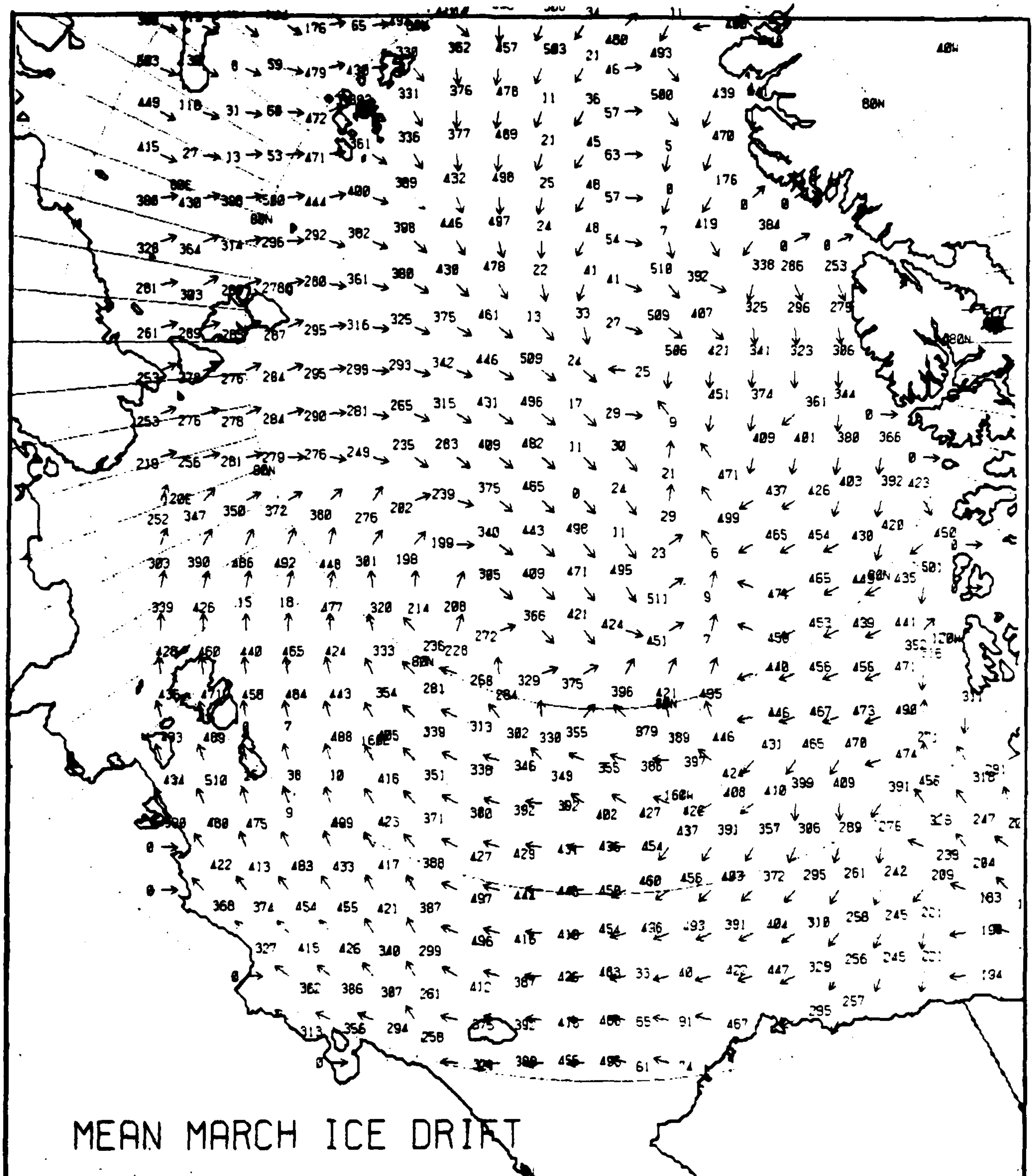


AVERAGE ICE GROWTH FOR FEBRUARY
CONTOUR INTERVAL IS 1 CM
LABELS ARE CM OF GROWTH PER DAY


80N
80N
120E
.005
.00
80N
160E
80N
160W
120W
.10
.00
.13
FLEET NUMERICAL OCEANOGRAPHY C
AVERAGE OPEN WATER GROWTH FOR FEBRUARY
CONTOUR INTERVAL IS CM
LABELS ARE CM OF GROWTH PER DAY

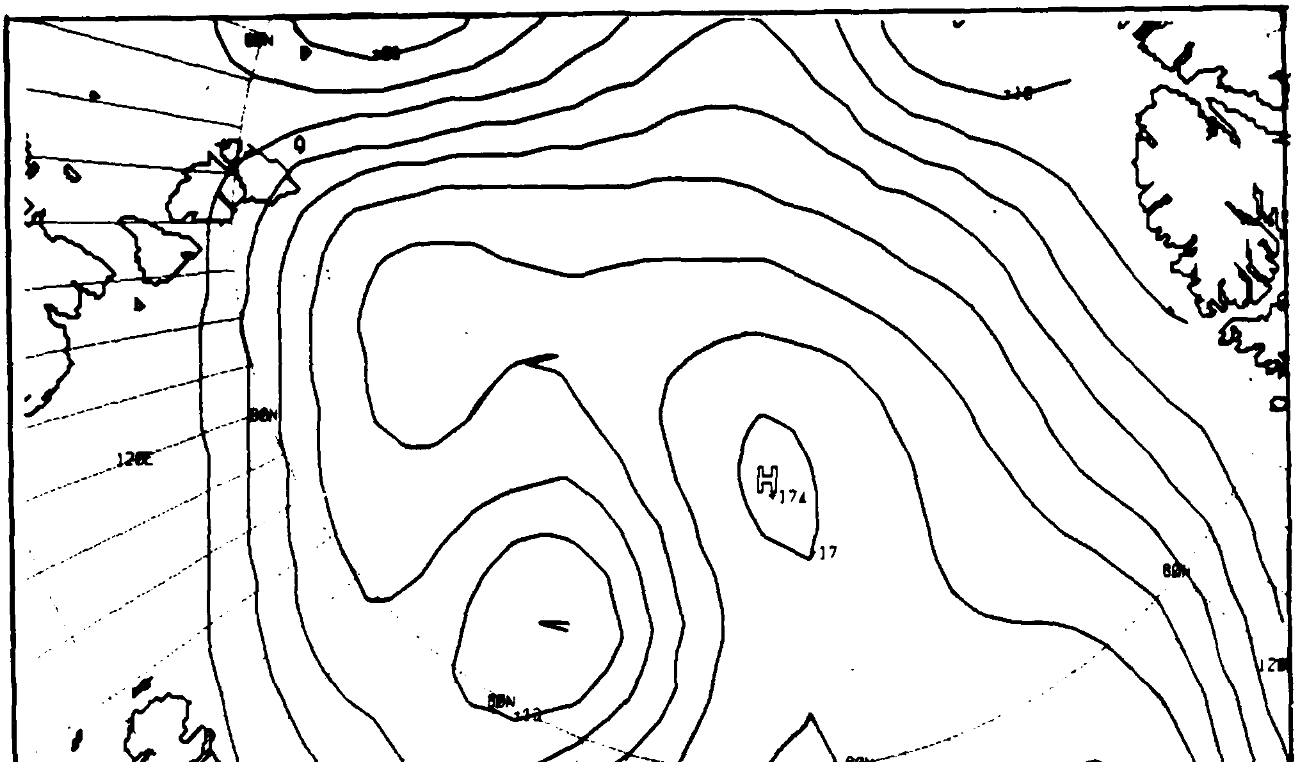


AVERAGE MARCH WIND DATA

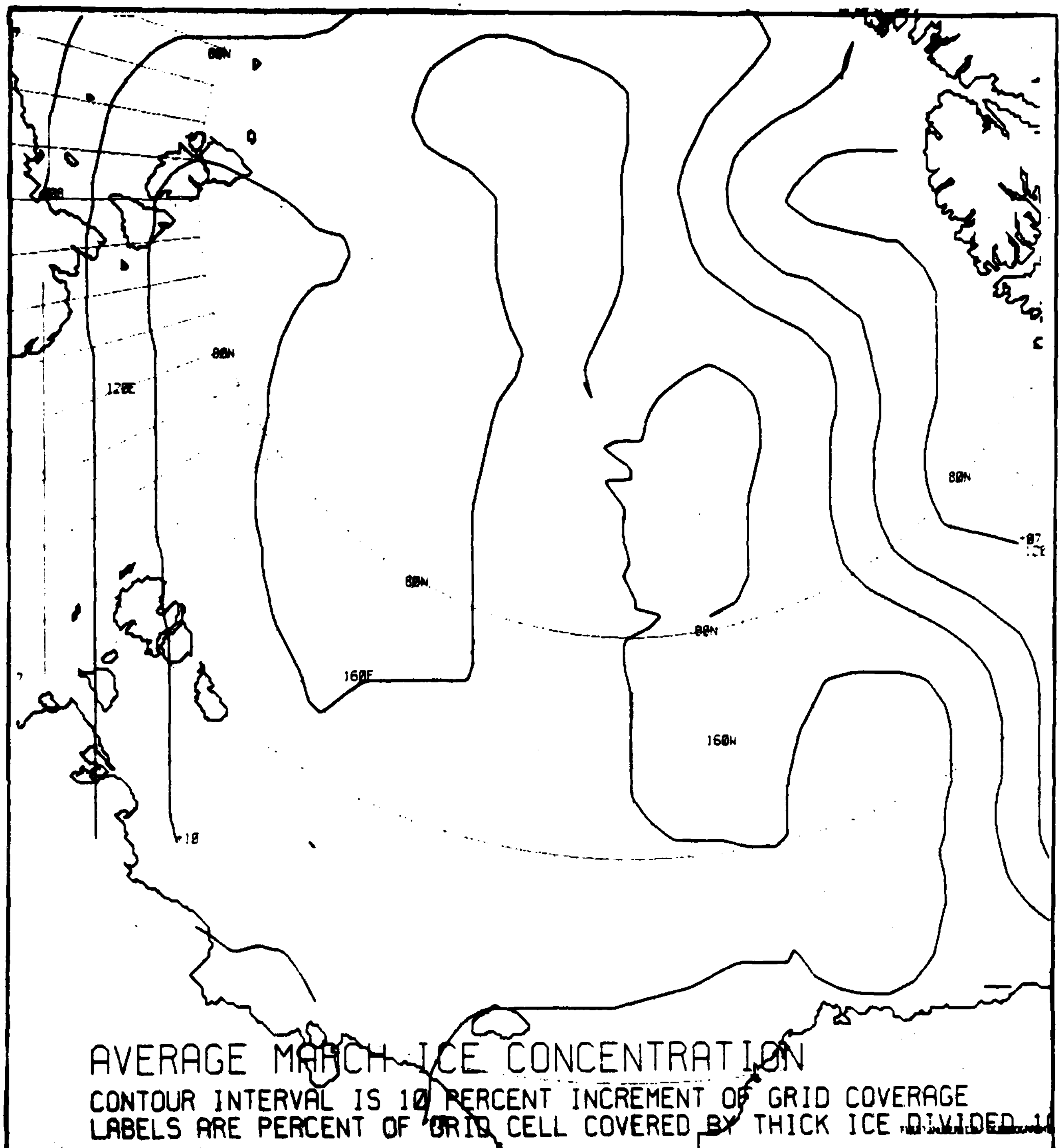


MEAN MARCH ICE DRIFT

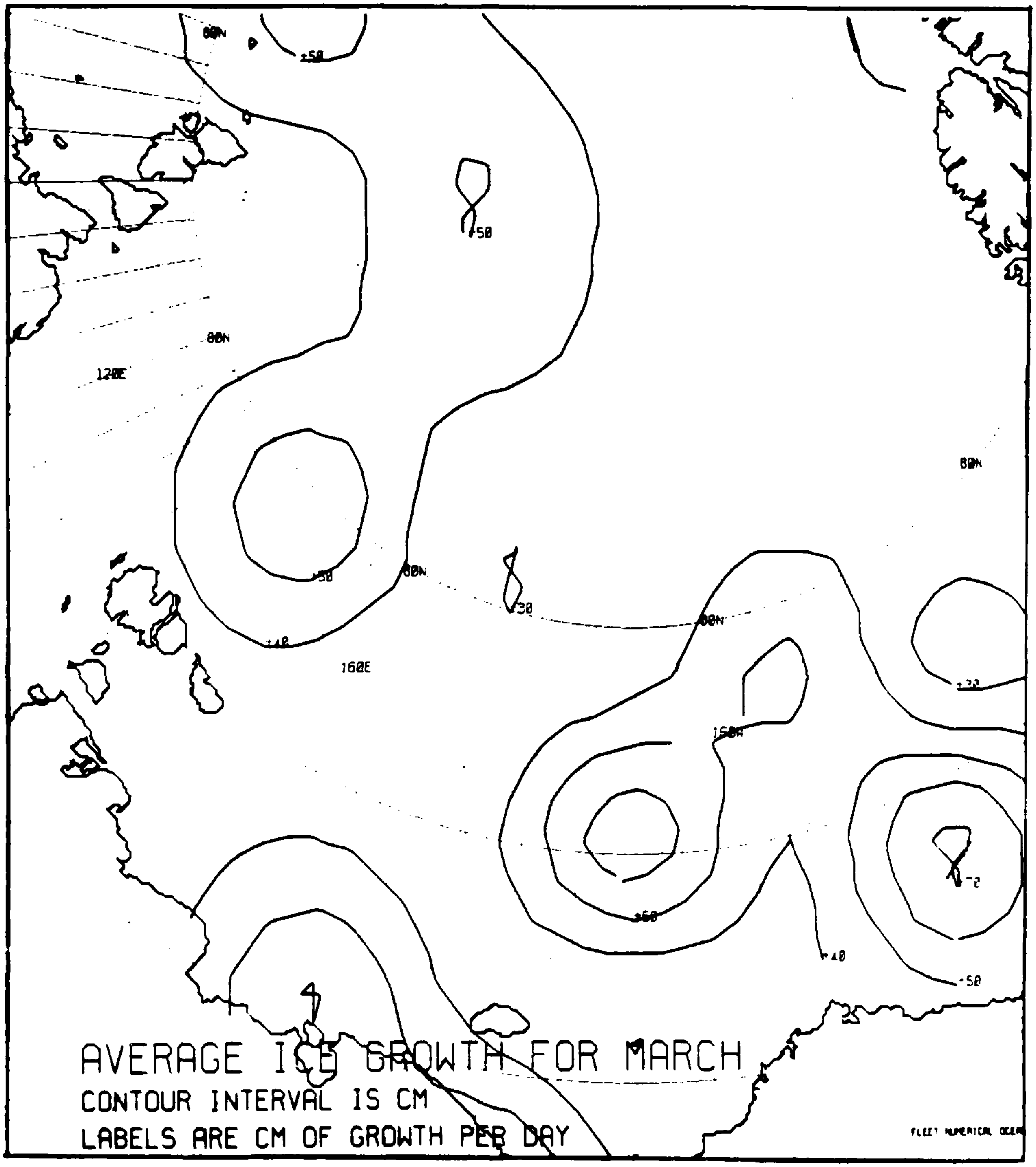
LABEL DIVIDED BY 100 GIVES NM OF ICE MOVEMENT IN 24 HRS



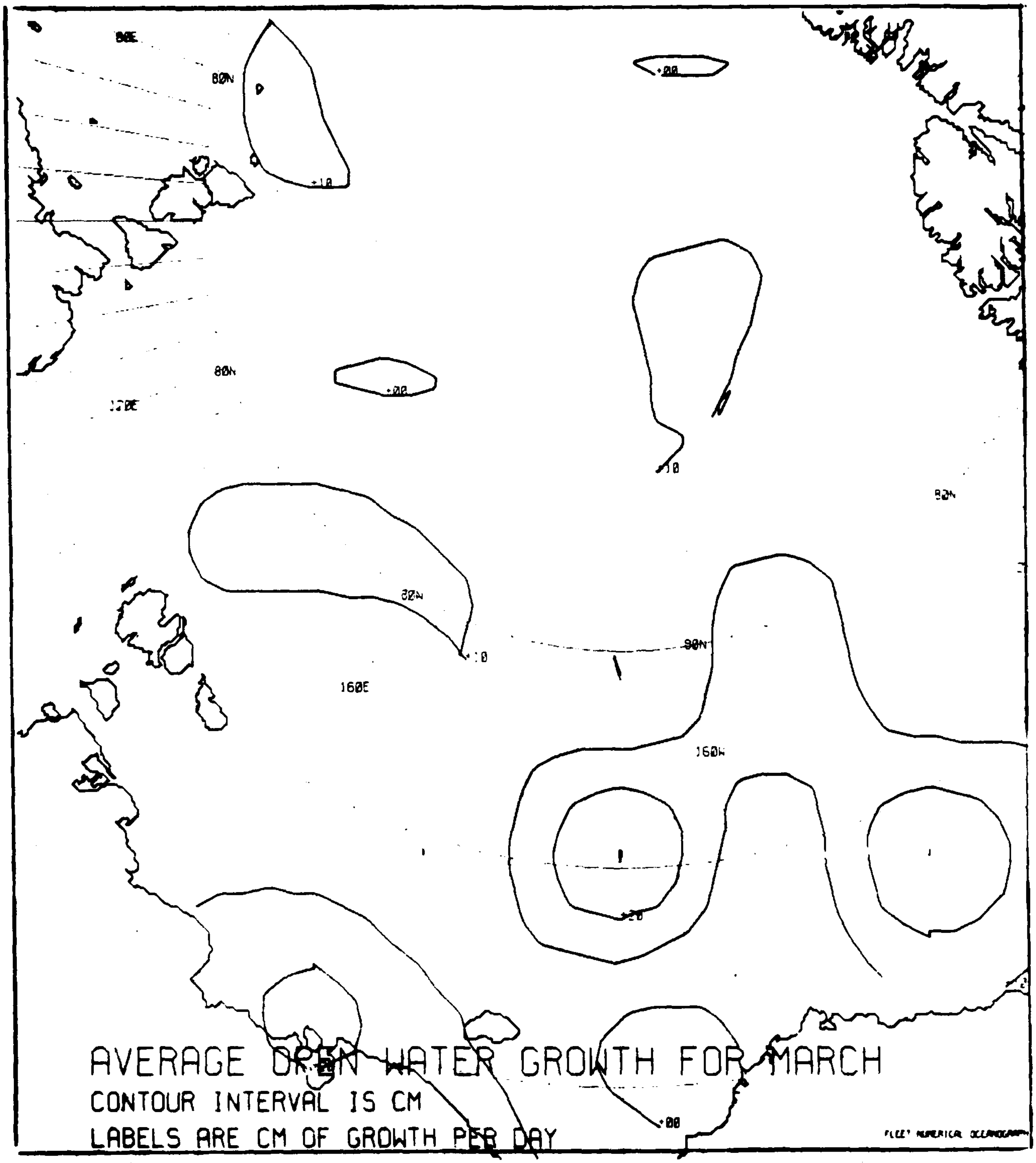
80N
120E
H
174
17
80N
112
80N
160E
160W
11
12
13
16
AVERAGE MARCH ICE THICKNESS
CONTOUR INTERVAL IS 10 CM
LABEL TIMES 10 GIVES CM OF ICE IN GRID CELL
FLEET NUMERICAL OCEANOGRAPH



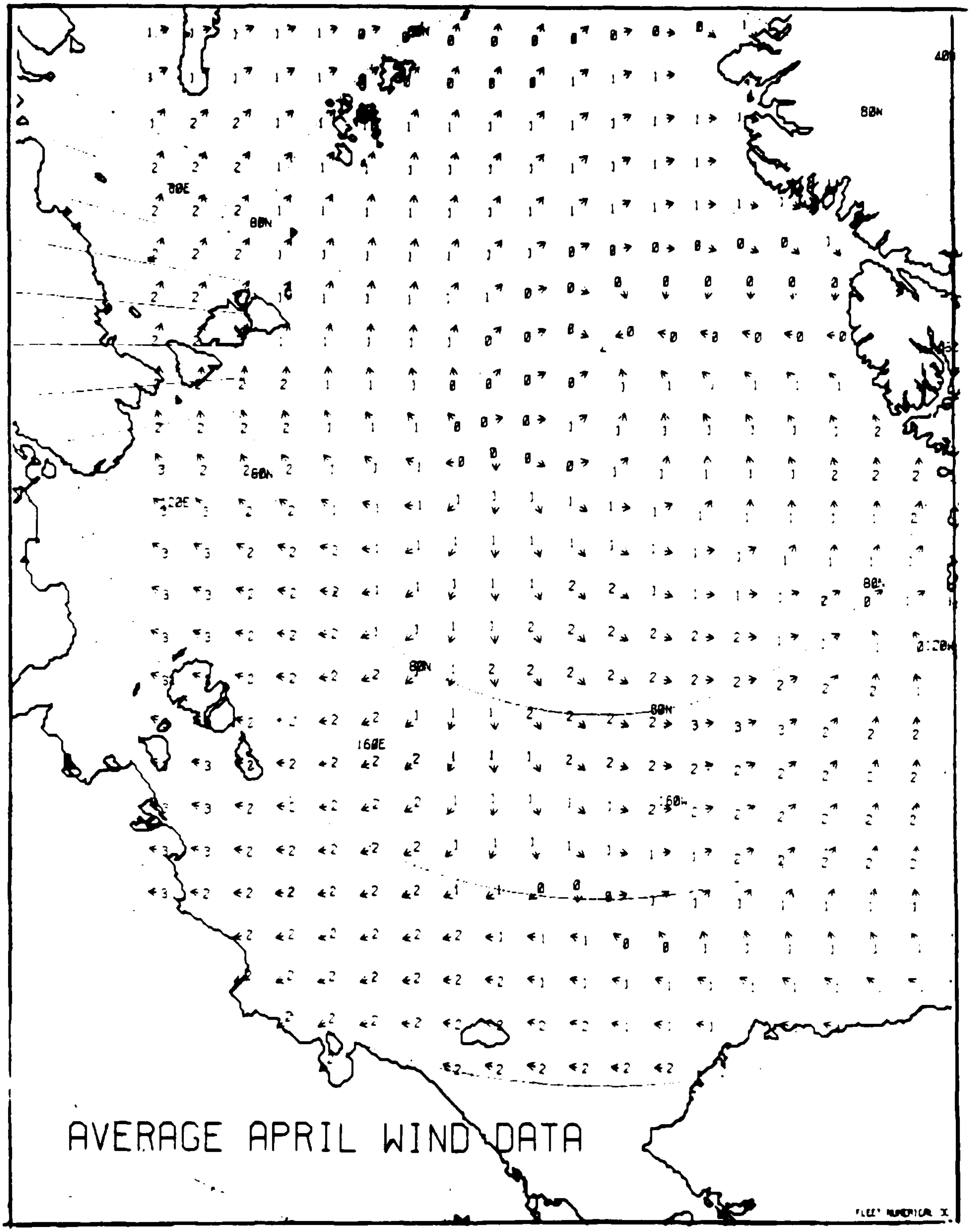
AVERAGE MARCH ICE CONCENTRATION
CONTOUR INTERVAL IS 10 PERCENT INCREMENT OF GRID COVERAGE
LABELS ARE PERCENT OF GRID CELL COVERED BY THICK ICE DIVIDED 1



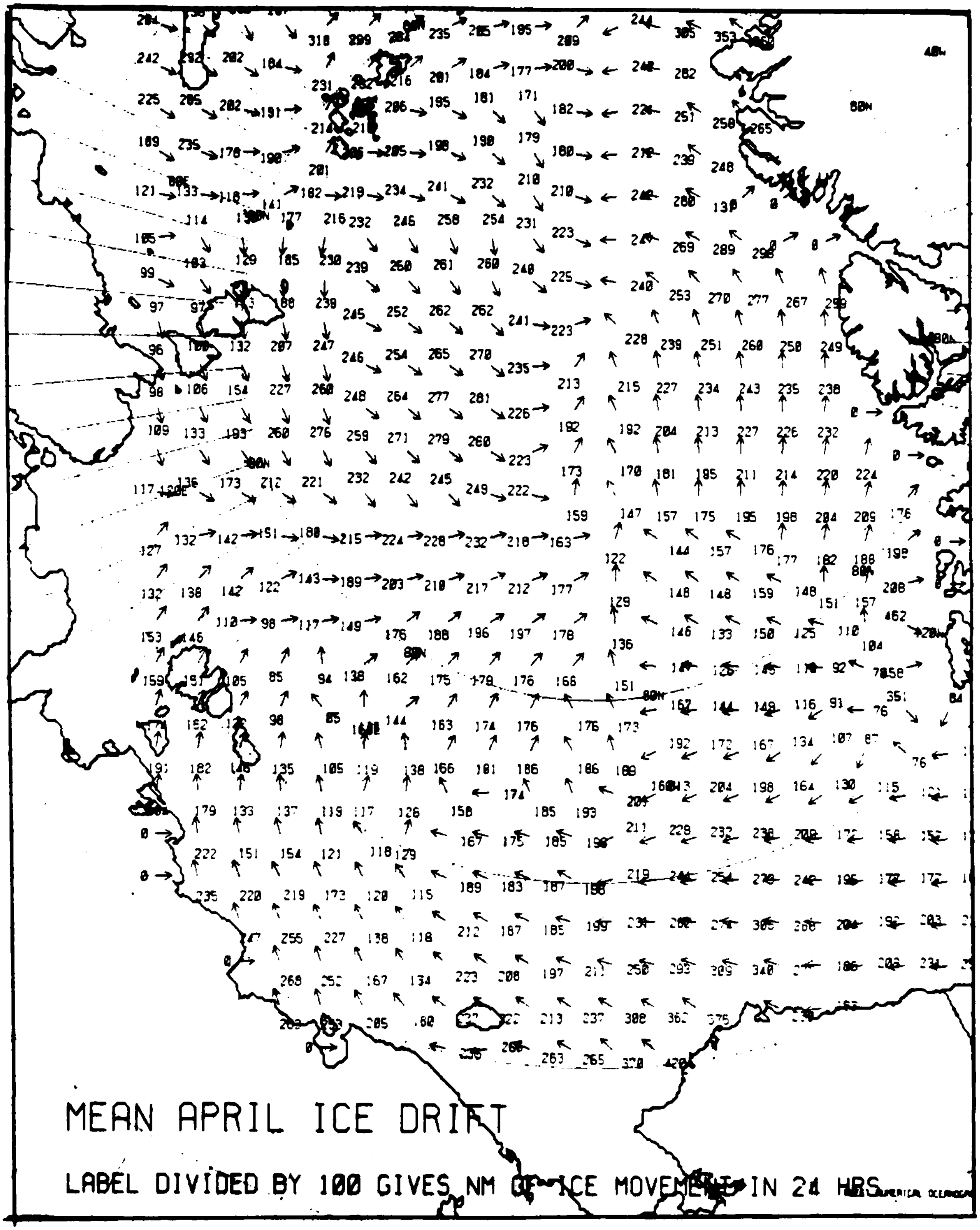
80N
+50
+50
80N
120E
80N
+50
80N
+30
80N
+40
160E
+30
150W
+50
+2
+40
-50
AVERAGE ICE GROWTH FOR MARCH
CONTOUR INTERVAL IS CM
LABELS ARE CM OF GROWTH PER DAY



AVERAGE OPEN WATER GROWTH FOR MARCH
CONTOUR INTERVAL IS CM
LABELS ARE CM OF GROWTH PER DAY

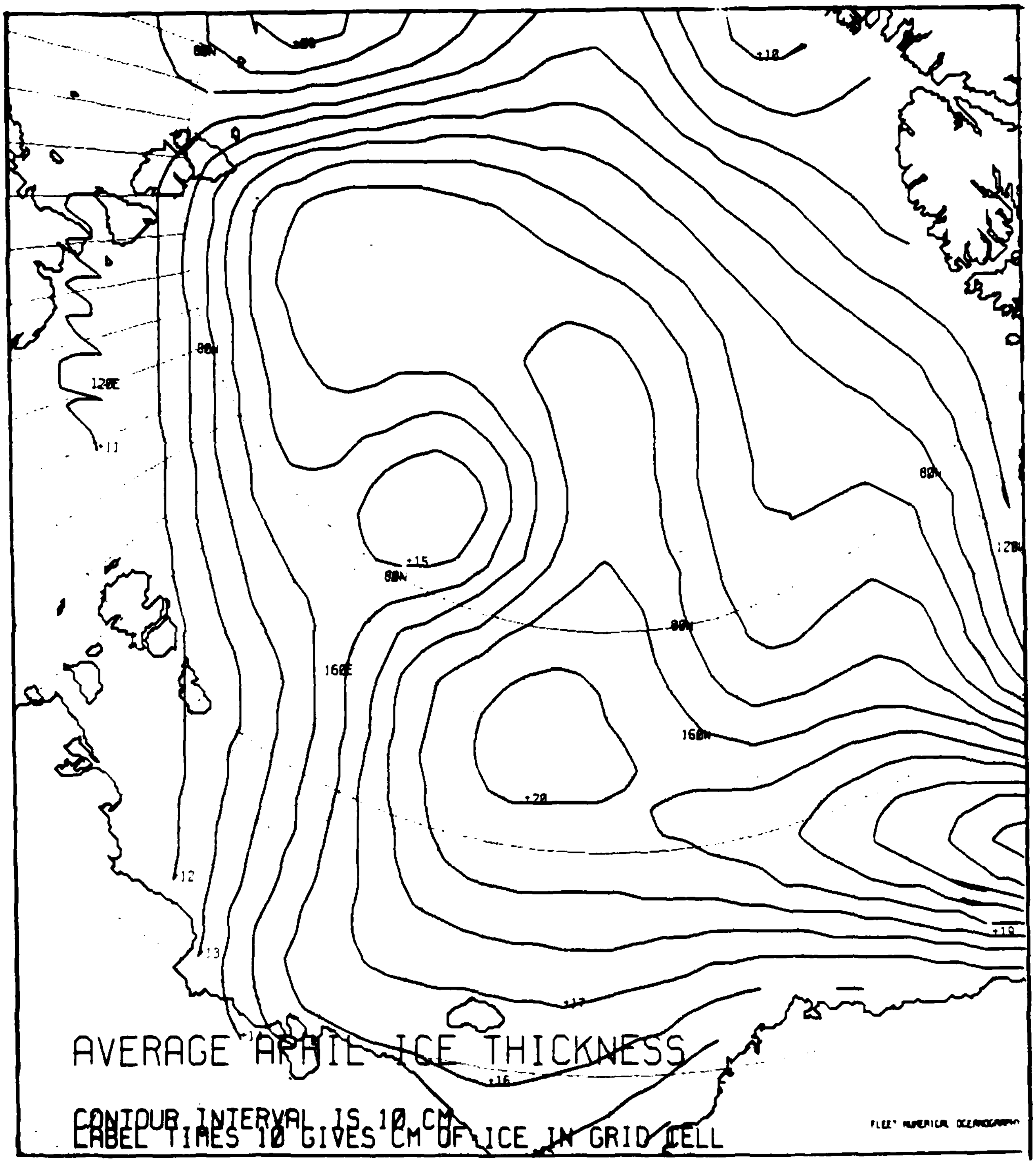


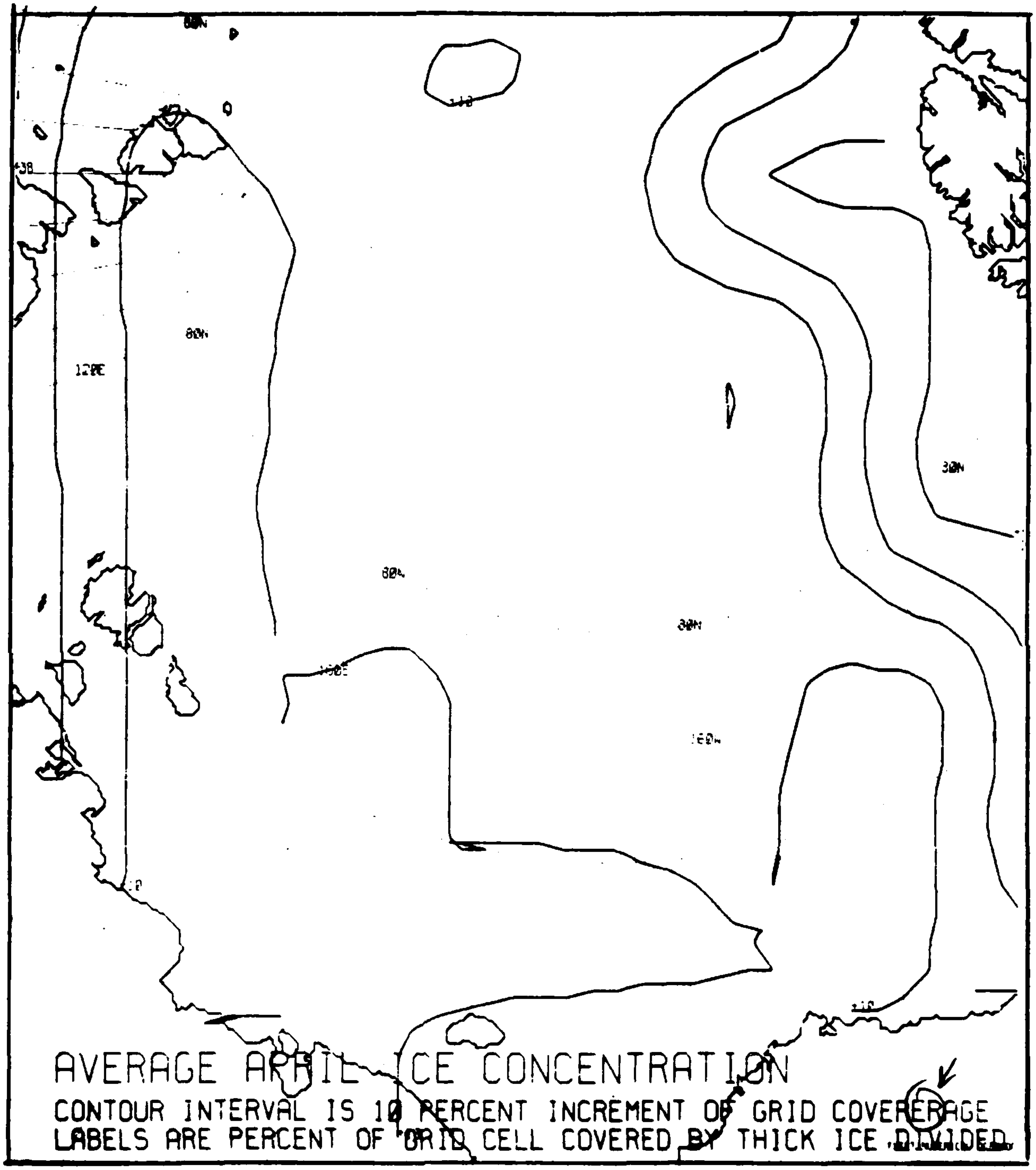
AVERAGE APRIL WIND DATA

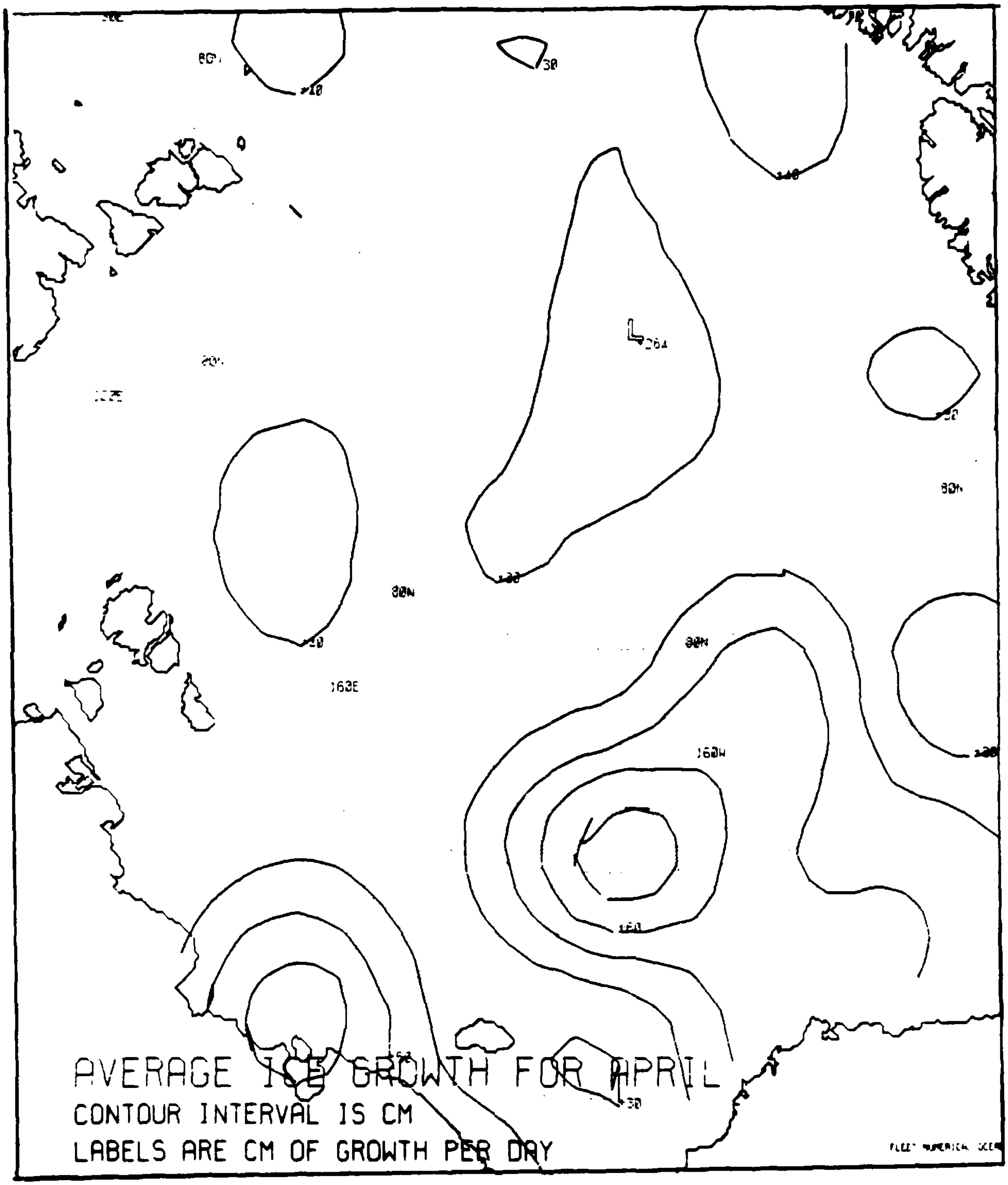


MEAN APRIL ICE DRIFT

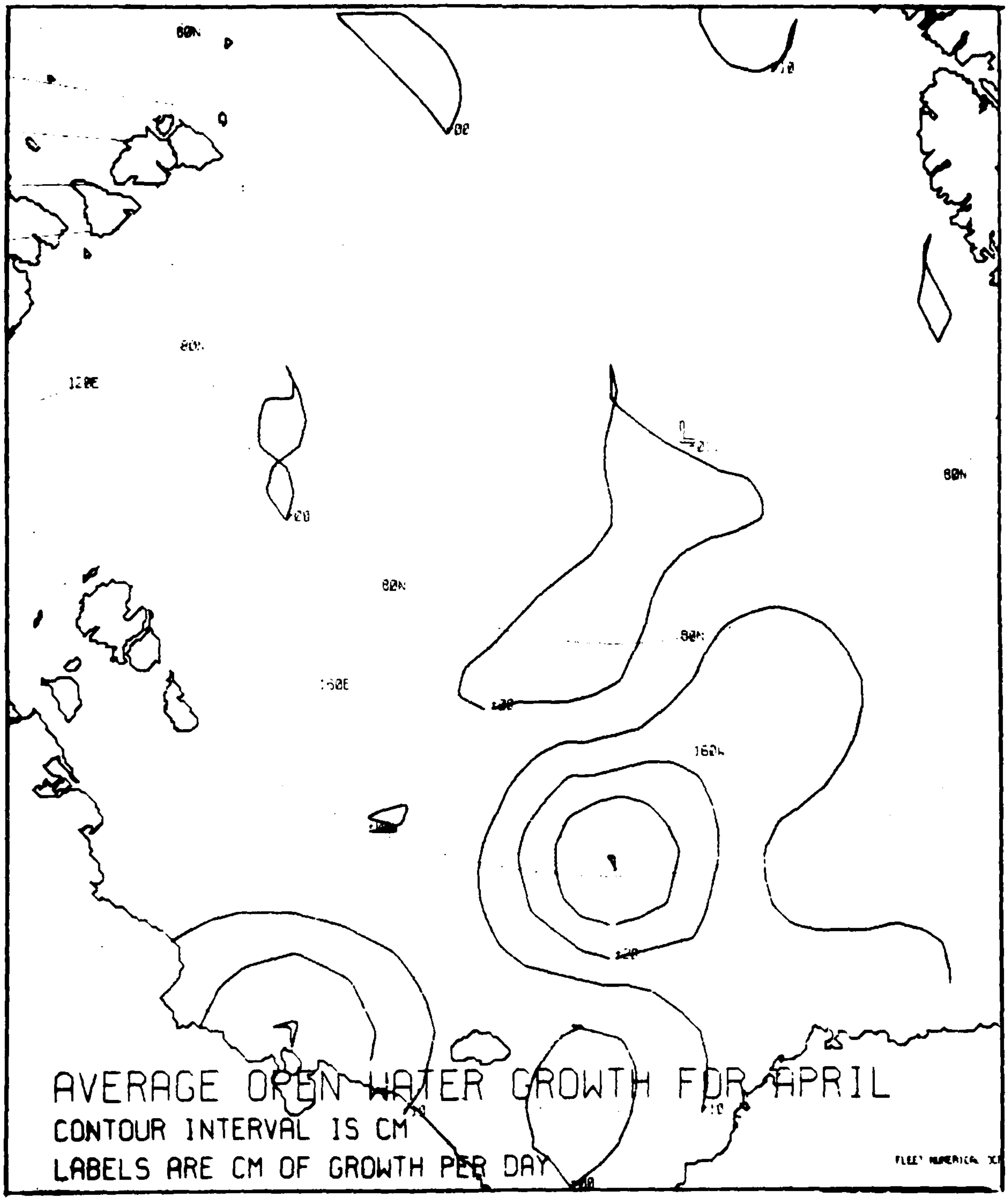
LABEL DIVIDED BY 100 GIVES NM OF ICE MOVEMENT IN 24 HRS

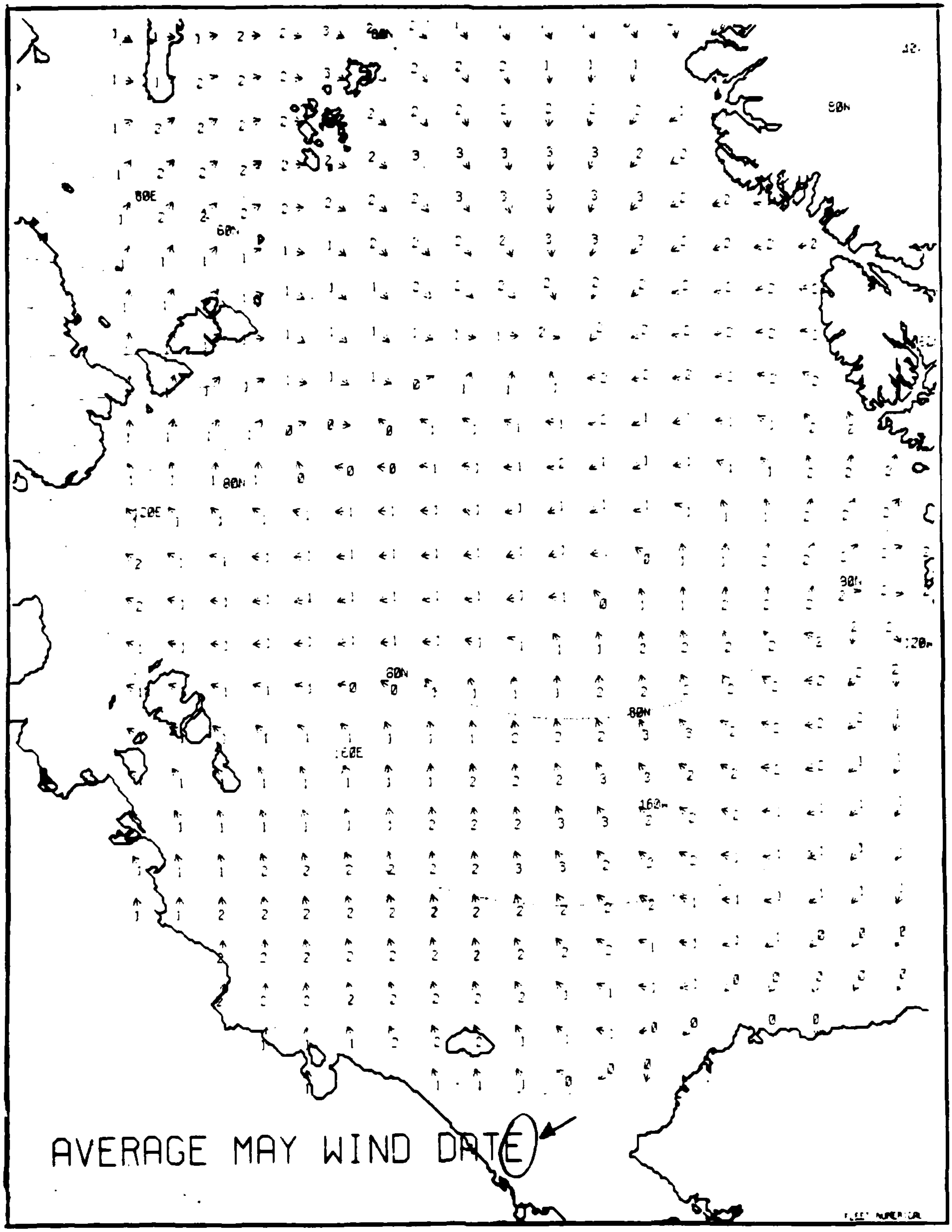

AVERAGE APRIL ICE THICKNESS
CONTOUR INTERVAL IS 10 CM
LABEL TIMES 10 GIVES CM OF ICE IN GRID CELL
FLEET NUMERICAL OCEANOGRAPHY
120E
160E
80N
160W
120W


AVERAGE APRIL ICE CONCENTRATION
CONTOUR INTERVAL IS 10 PERCENT INCREMENT OF GRID COVERERAGE
LABELS ARE PERCENT OF GRID CELL COVERED BY THICK ICE DIVIDED

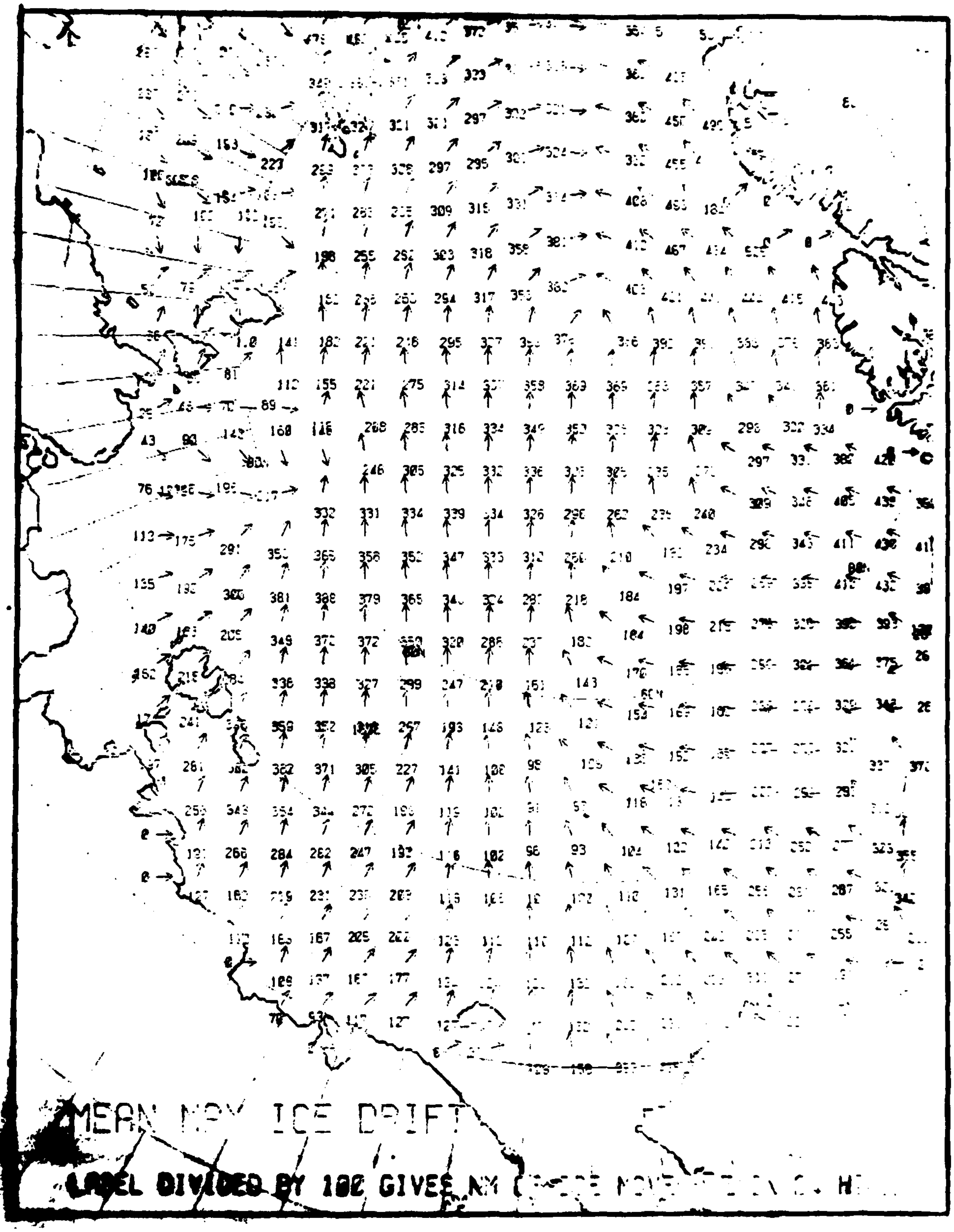


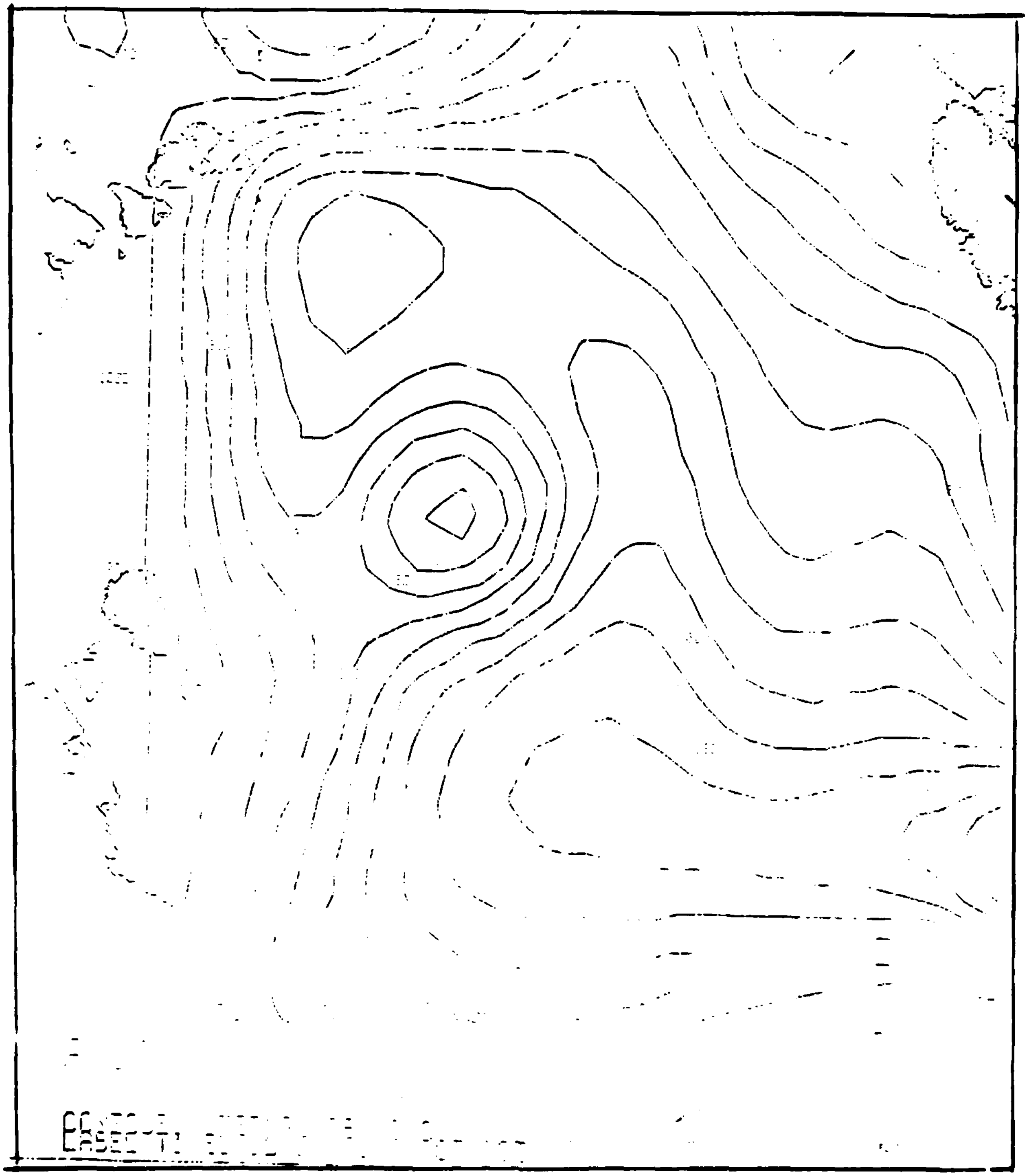
AVERAGE ICE GROWTH FOR APRIL
CONTOUR INTERVAL IS CM
LABELS ARE CM OF GROWTH PER DAY

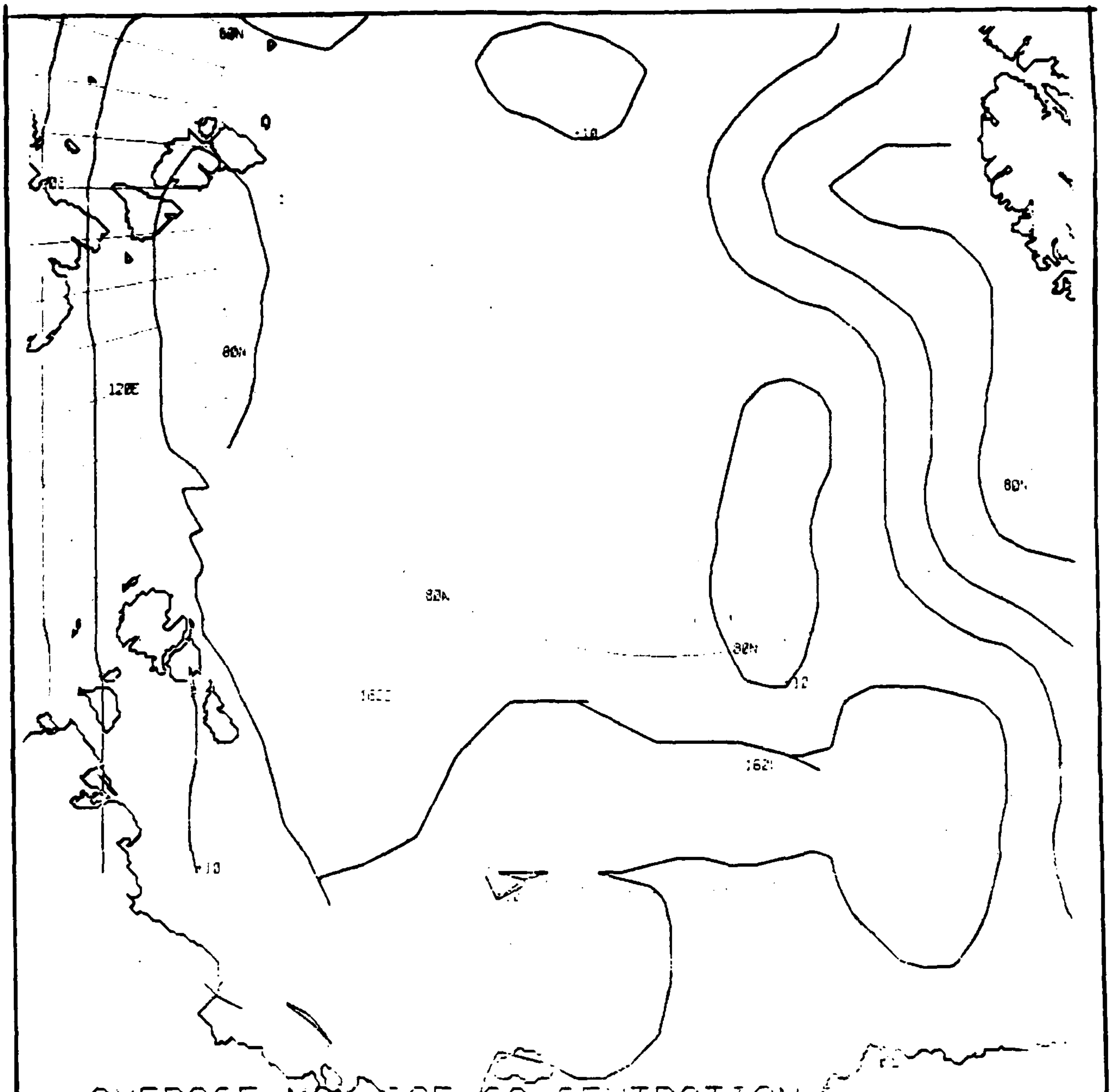

AVERAGE OPEN WATER GROWTH FOR APRIL
CONTOUR INTERVAL IS CM
LABELS ARE CM OF GROWTH PER DAY
80N
120E
160E
160W



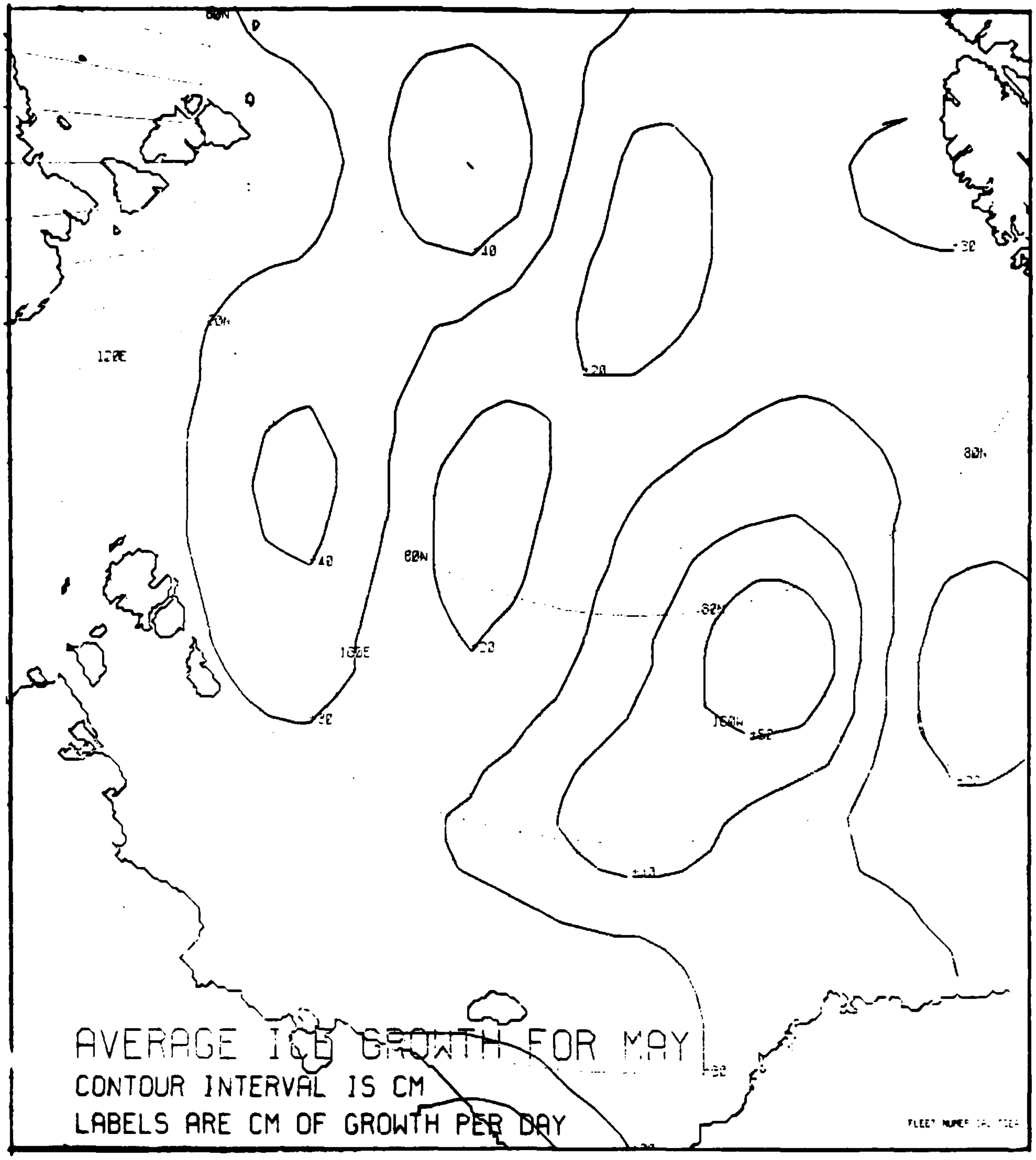
AVERAGE MAY WIND DATE


MEAN MAY ICE DRIFT
LABEL DIVIDED BY 100 GIVES NM

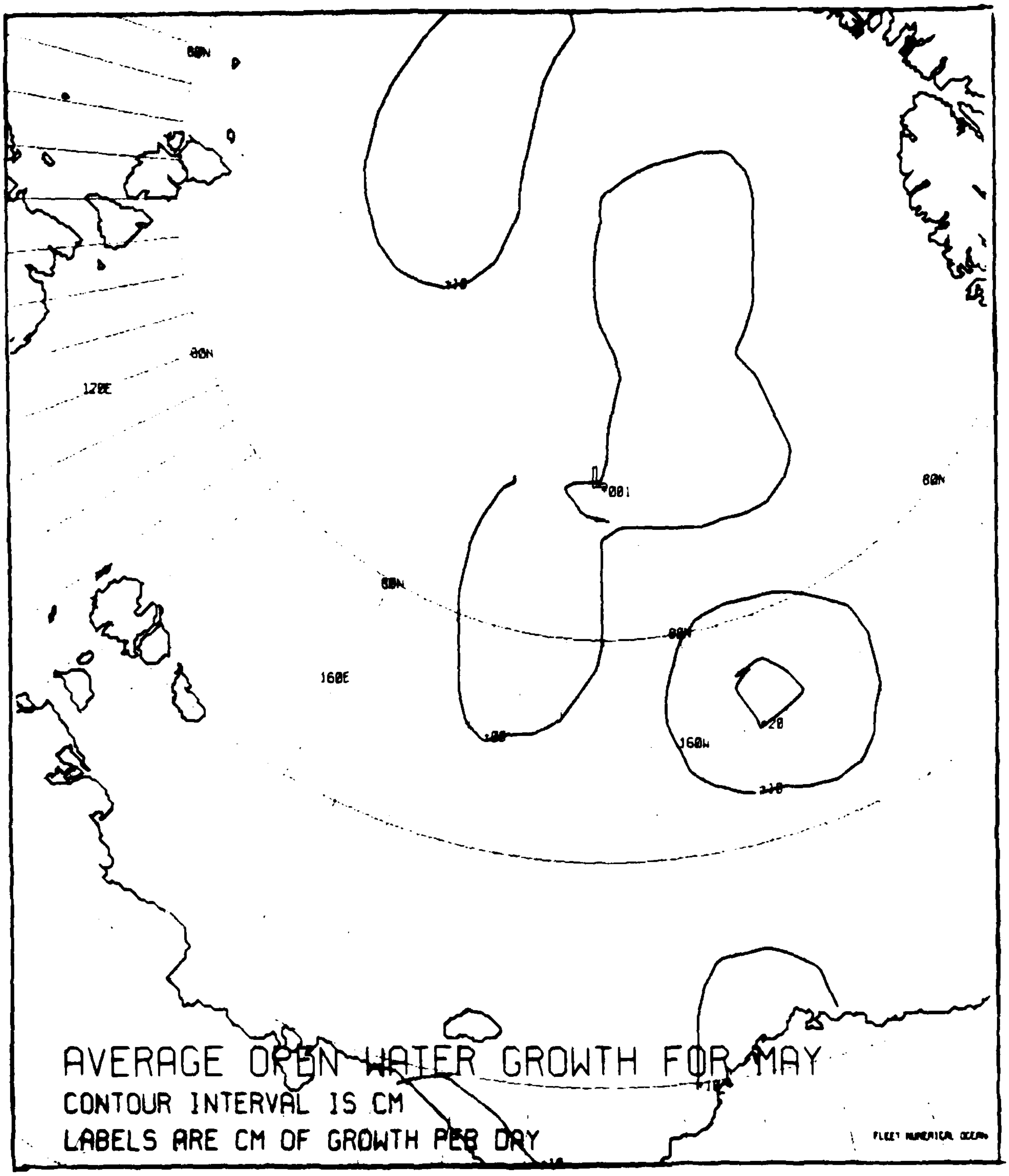




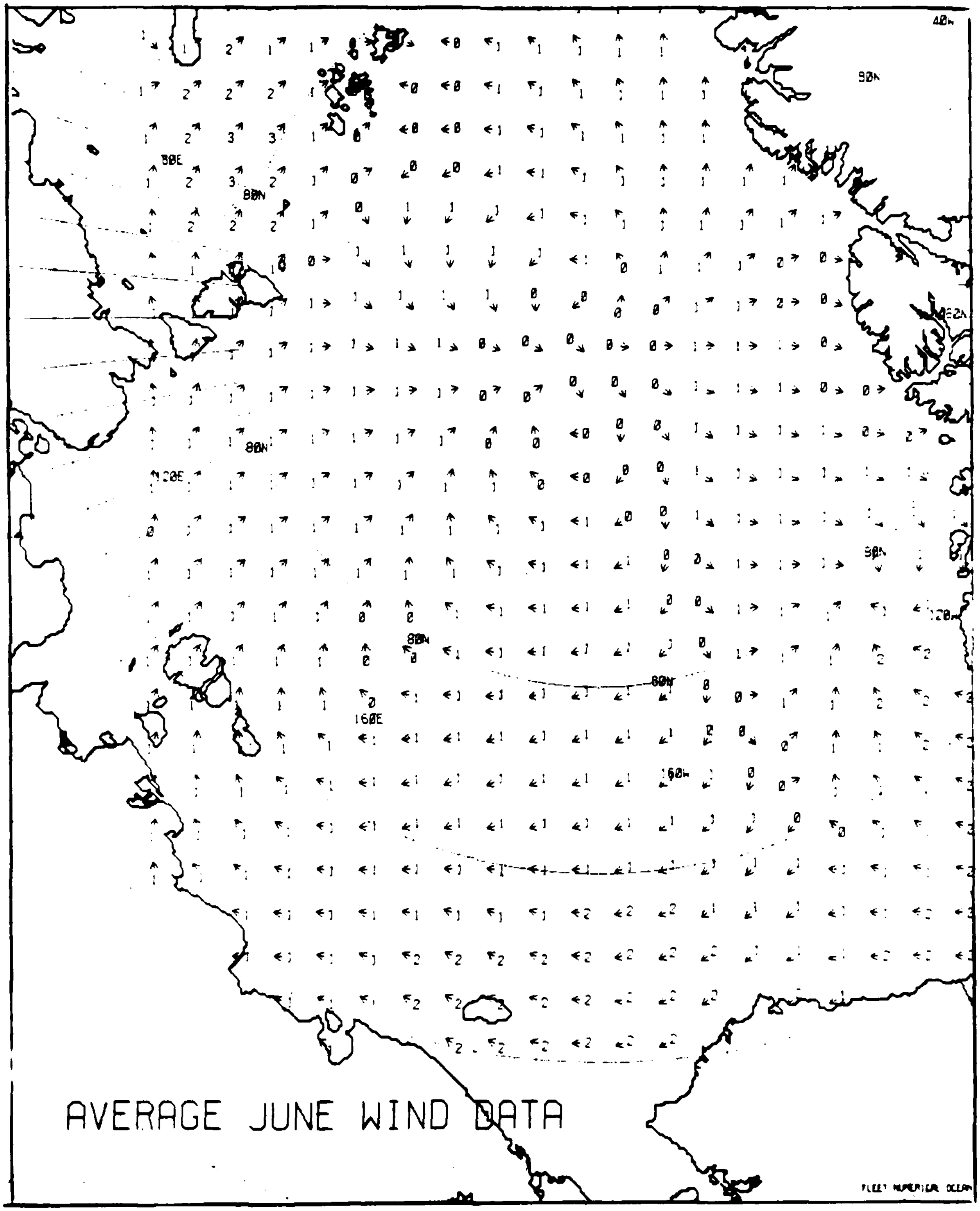
AVERAGE MAY ICE CONCENTRATION
CONTOUR INTERVAL IS 10 PERCENT INCREMENT OF GRID COVERAGE
LABELS ARE PERCENT OF GRID CELL COVERED BY THICK ICE

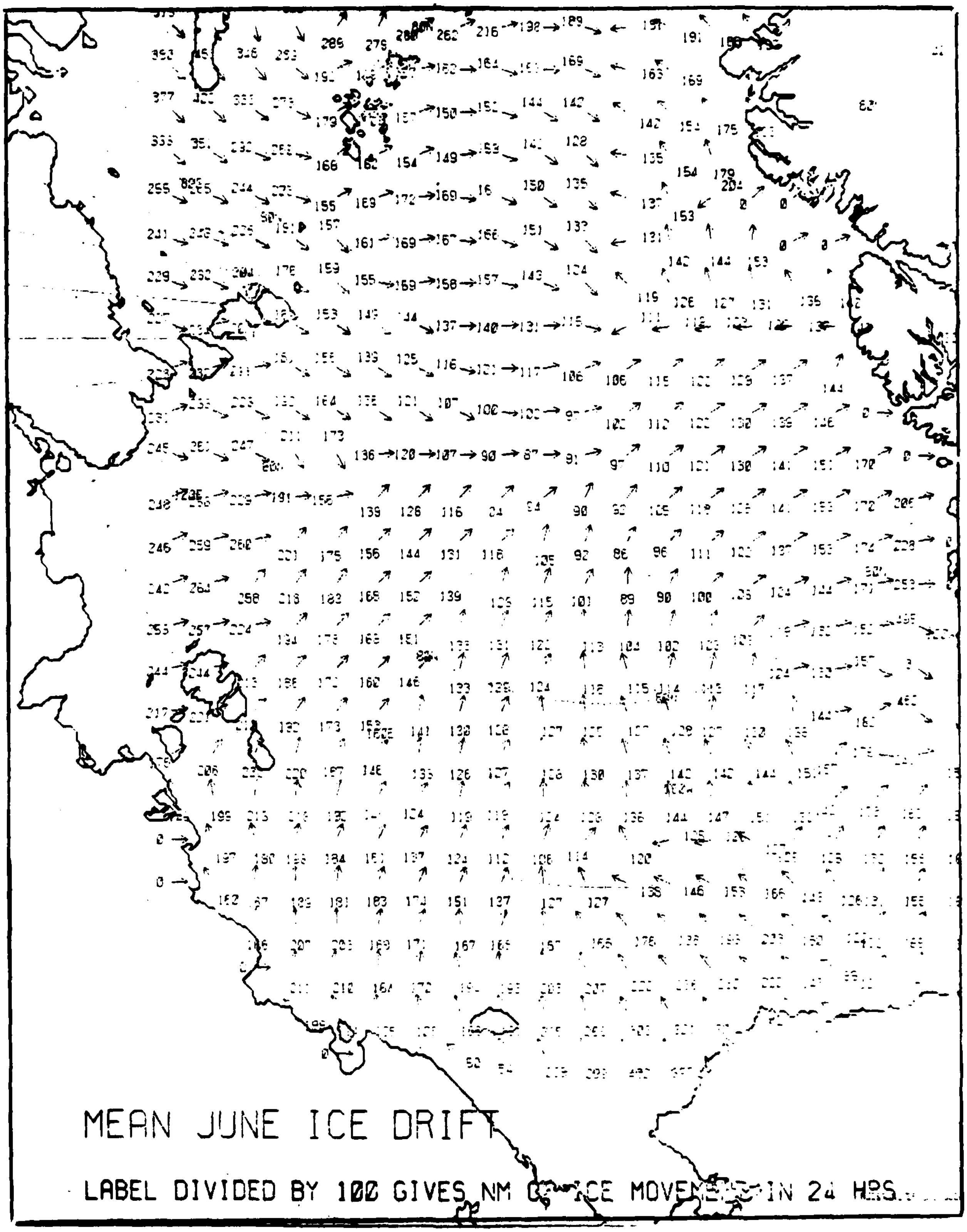


AVERAGE ICE GROWTH FOR MAY
CONTOUR INTERVAL IS CM
LABELS ARE CM OF GROWTH PER DAY



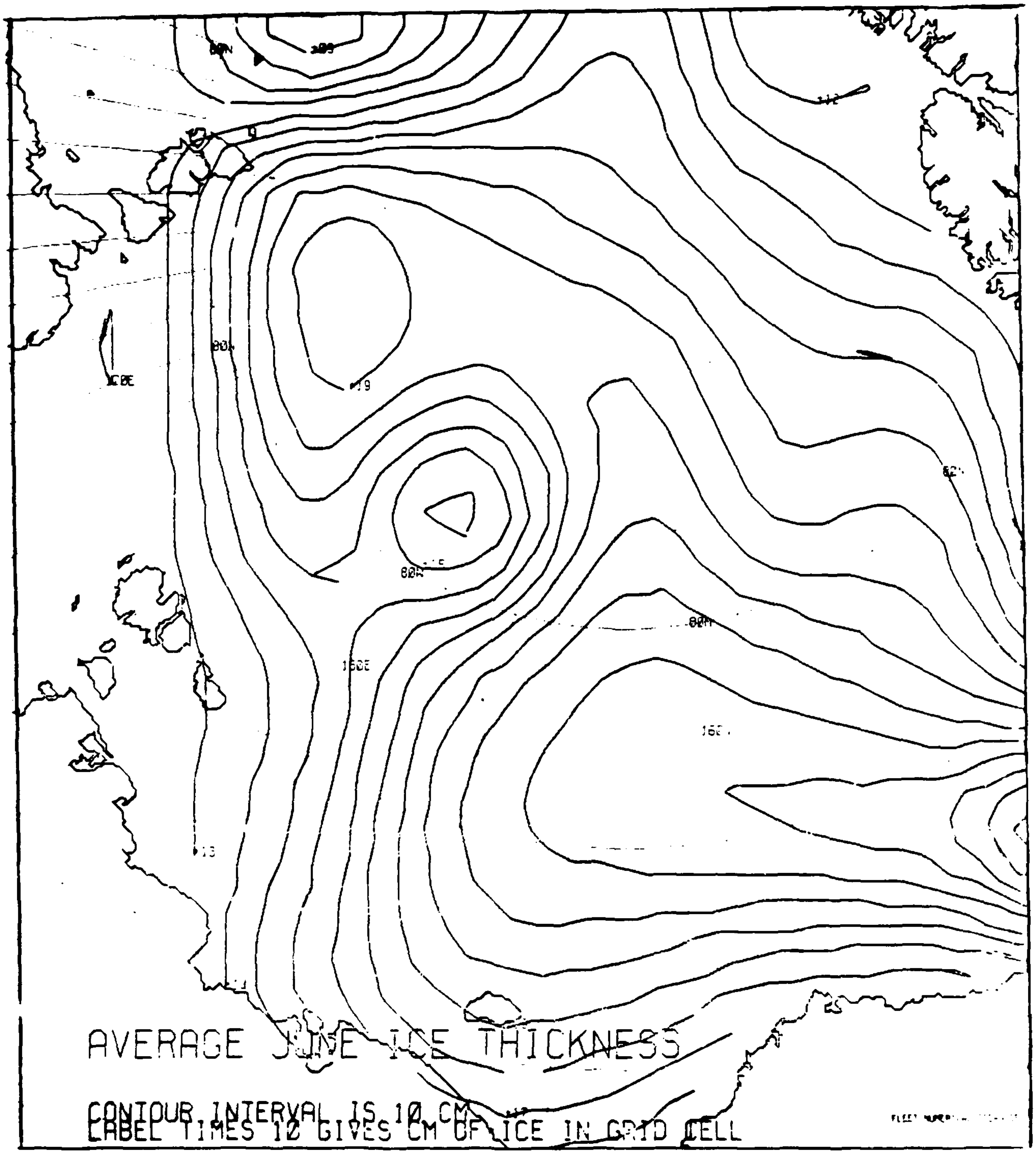
AVERAGE OPEN WATER GROWTH FOR MAY
CONTOUR INTERVAL IS CM
LABELS ARE CM OF GROWTH PER DAY

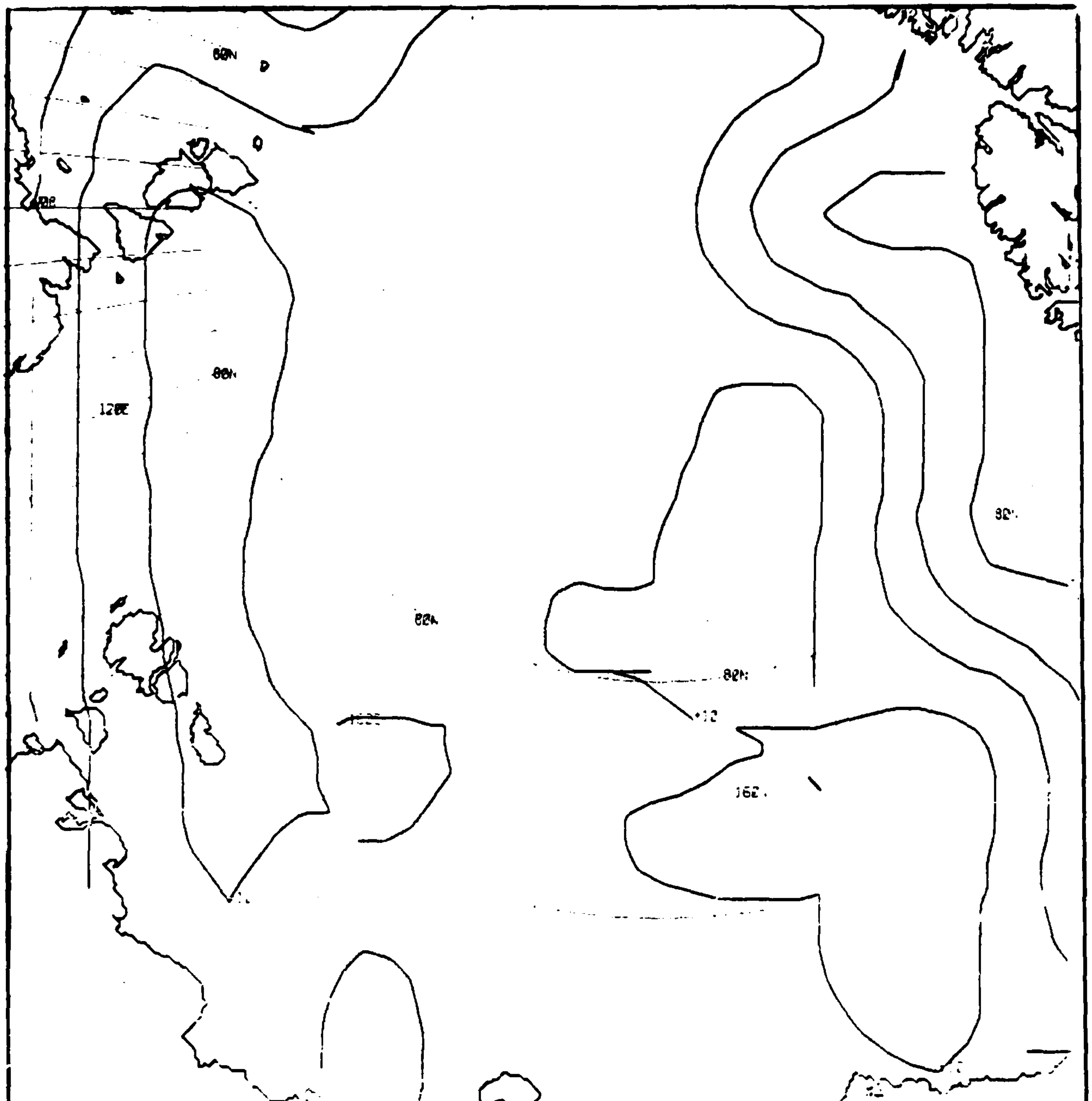

AVERAGE JUNE WIND DATA
FLEET NUMERICAL OCEAN



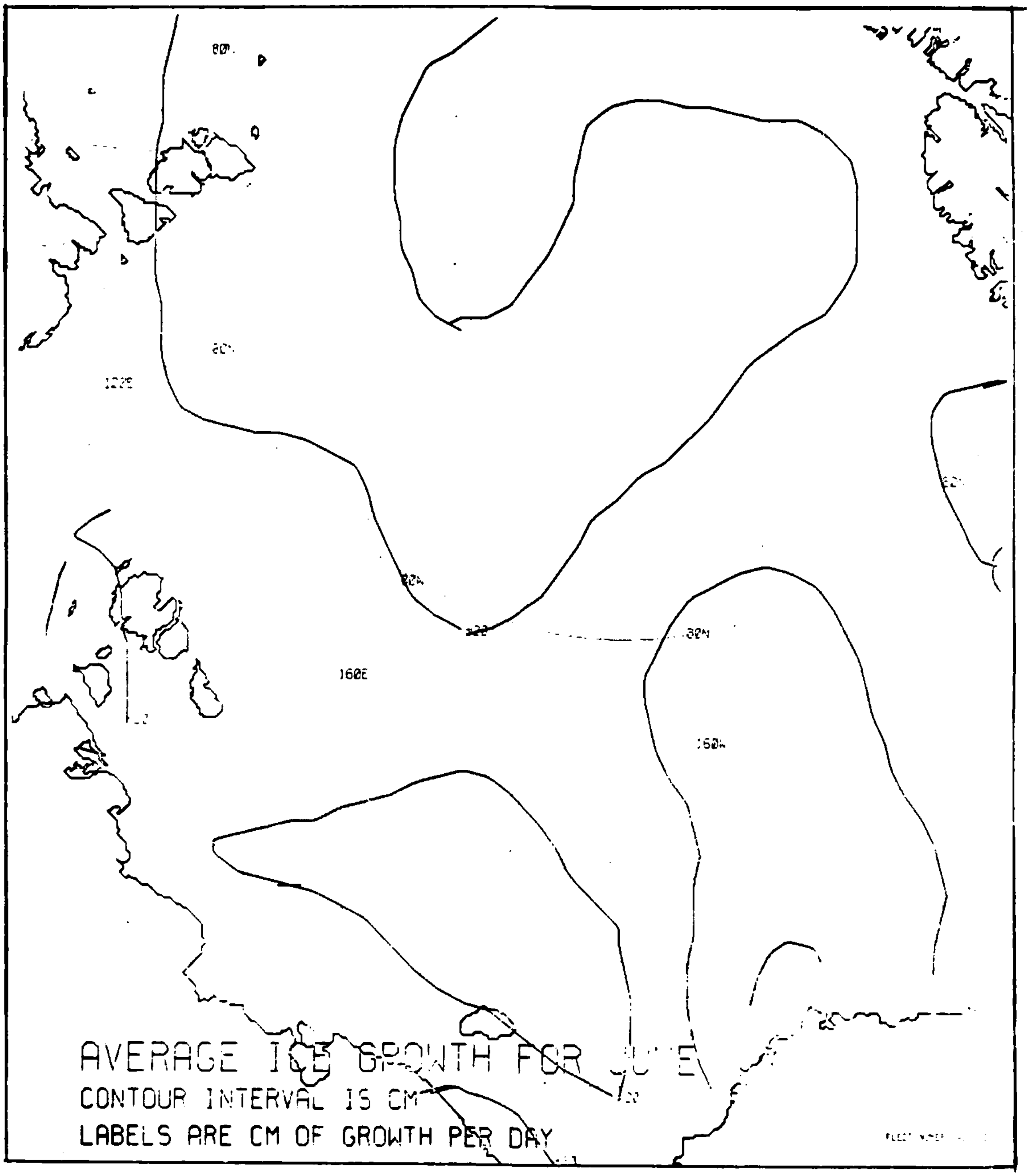
MEAN JUNE ICE DRIFT

LABEL DIVIDED BY 100 GIVES NM O[illegible] ICE MOVEME[illegible] IN 24 HRS.

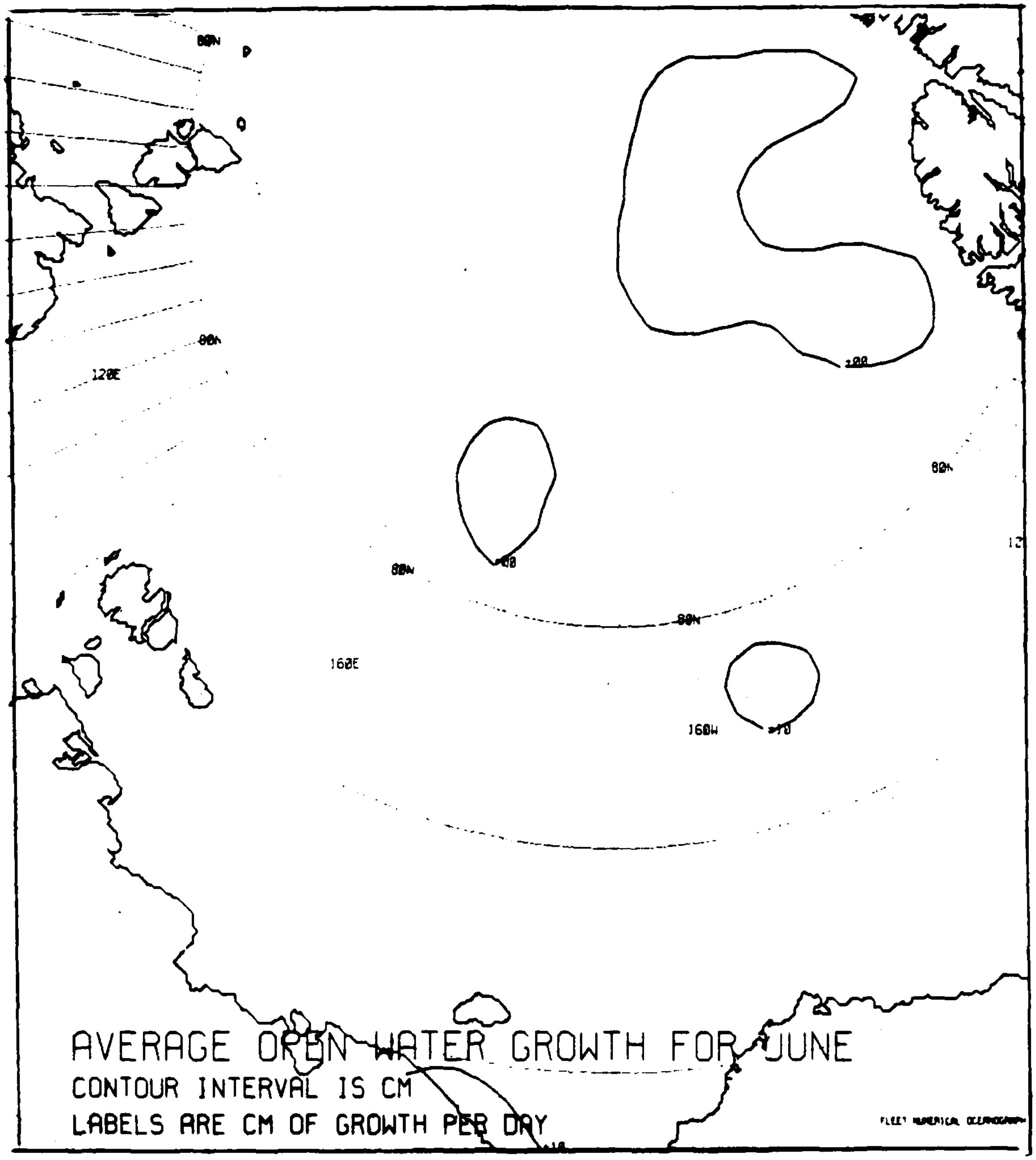

AVERAGE JUNE ICE THICKNESS
CONTOUR INTERVAL IS 10 CM
LABEL TIMES 10 GIVES CM OF ICE IN GRID CELL



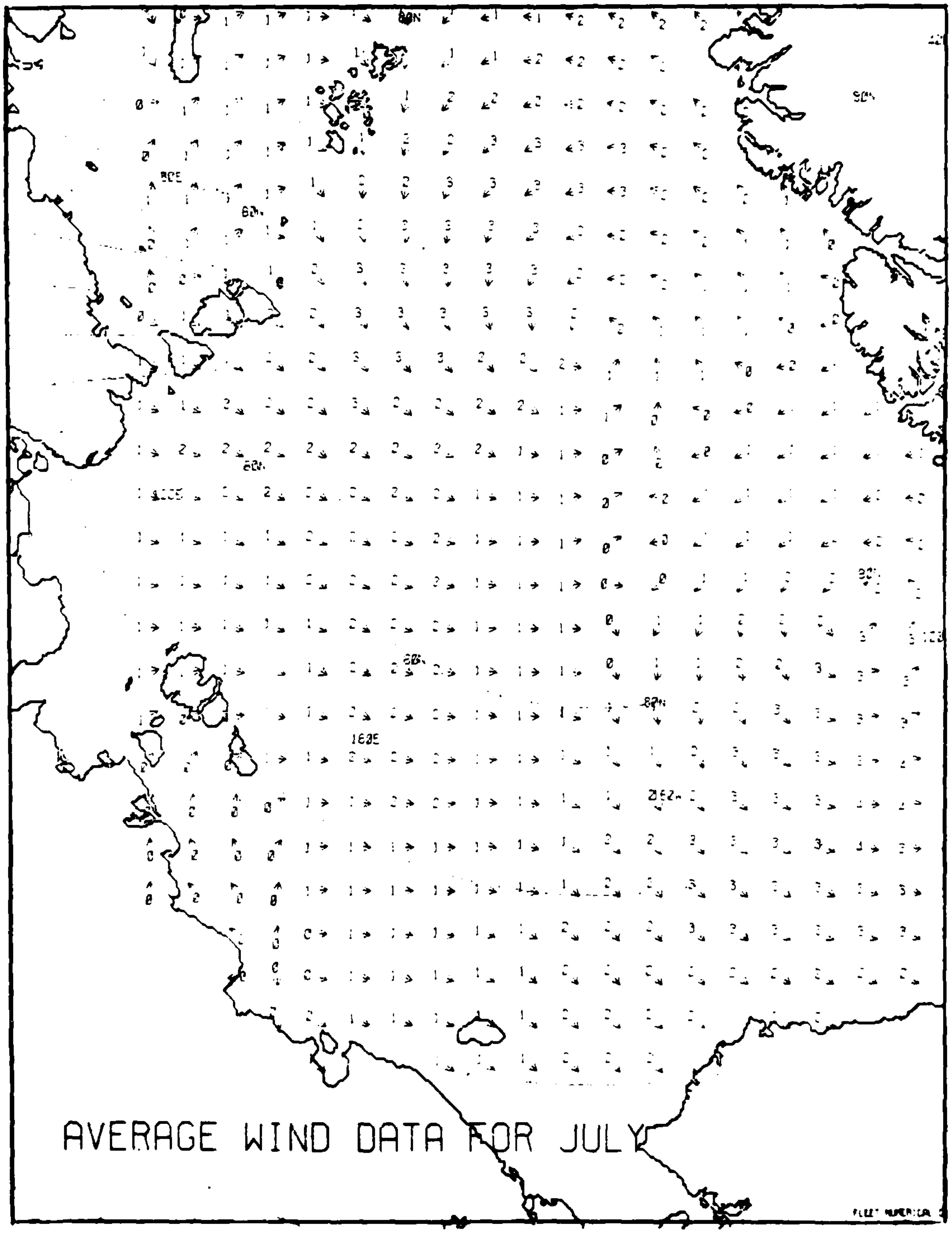
AVERAGE JUNE ICE CONCENTRATION
CONTOUR INTERVAL IS 10 PERCENT INCREMENT OF GRID COVERERAGE
LABELS ARE PERCENT OF GRID CELL COVERED BY THICK ICE DIVIDED

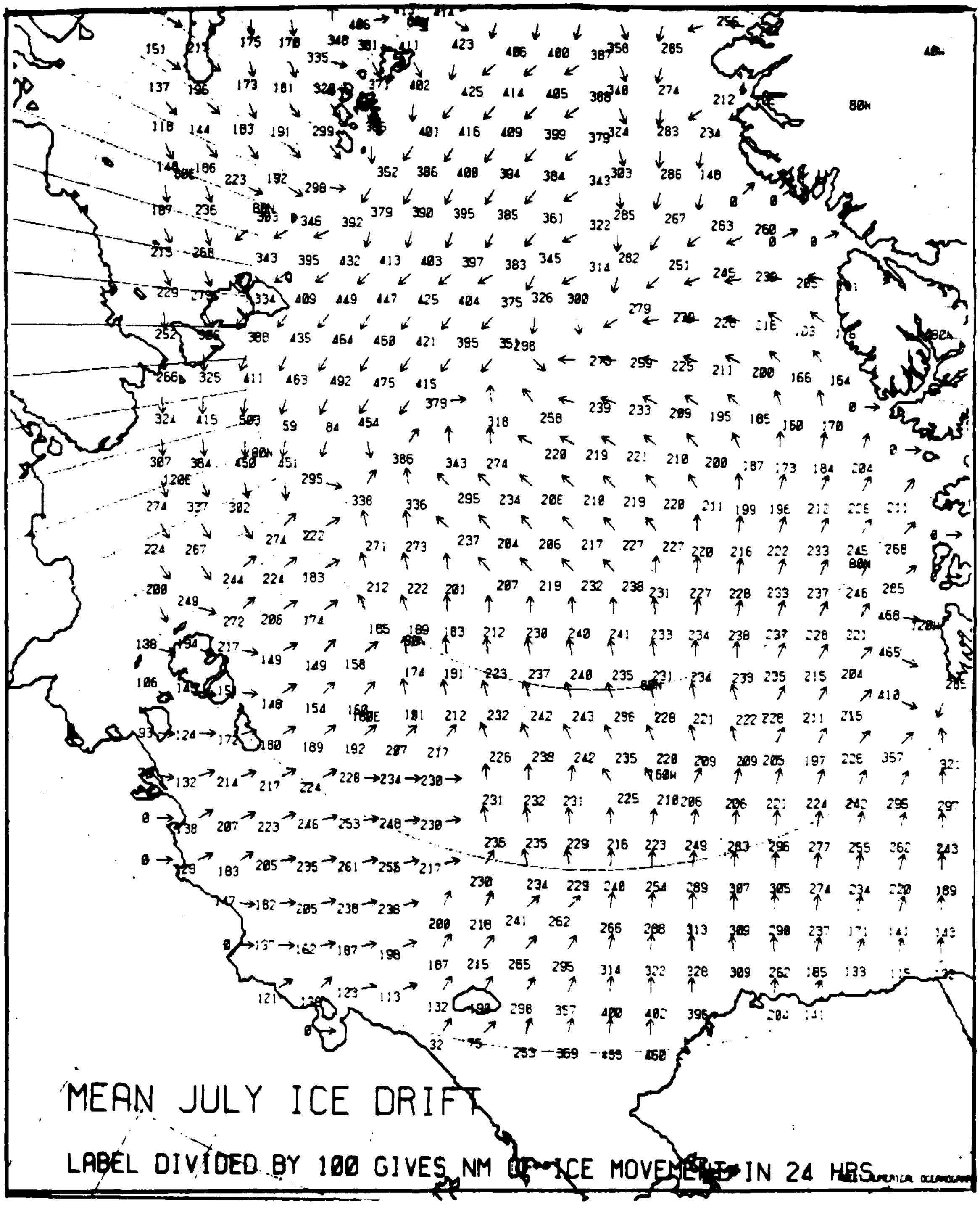


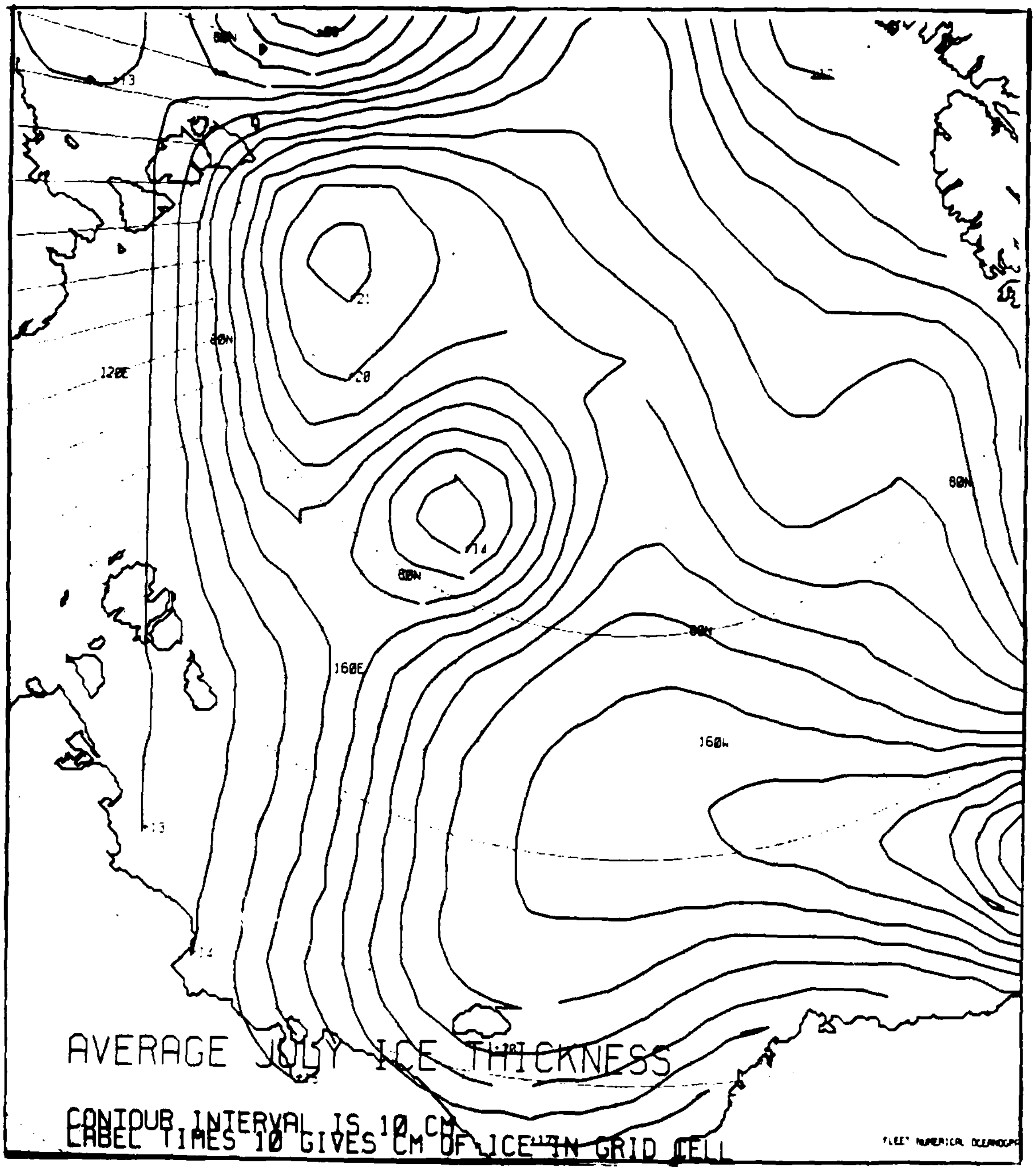
AVERAGE ICE GROWTH FOR JUNE
CONTOUR INTERVAL IS CM
LABELS ARE CM OF GROWTH PER DAY

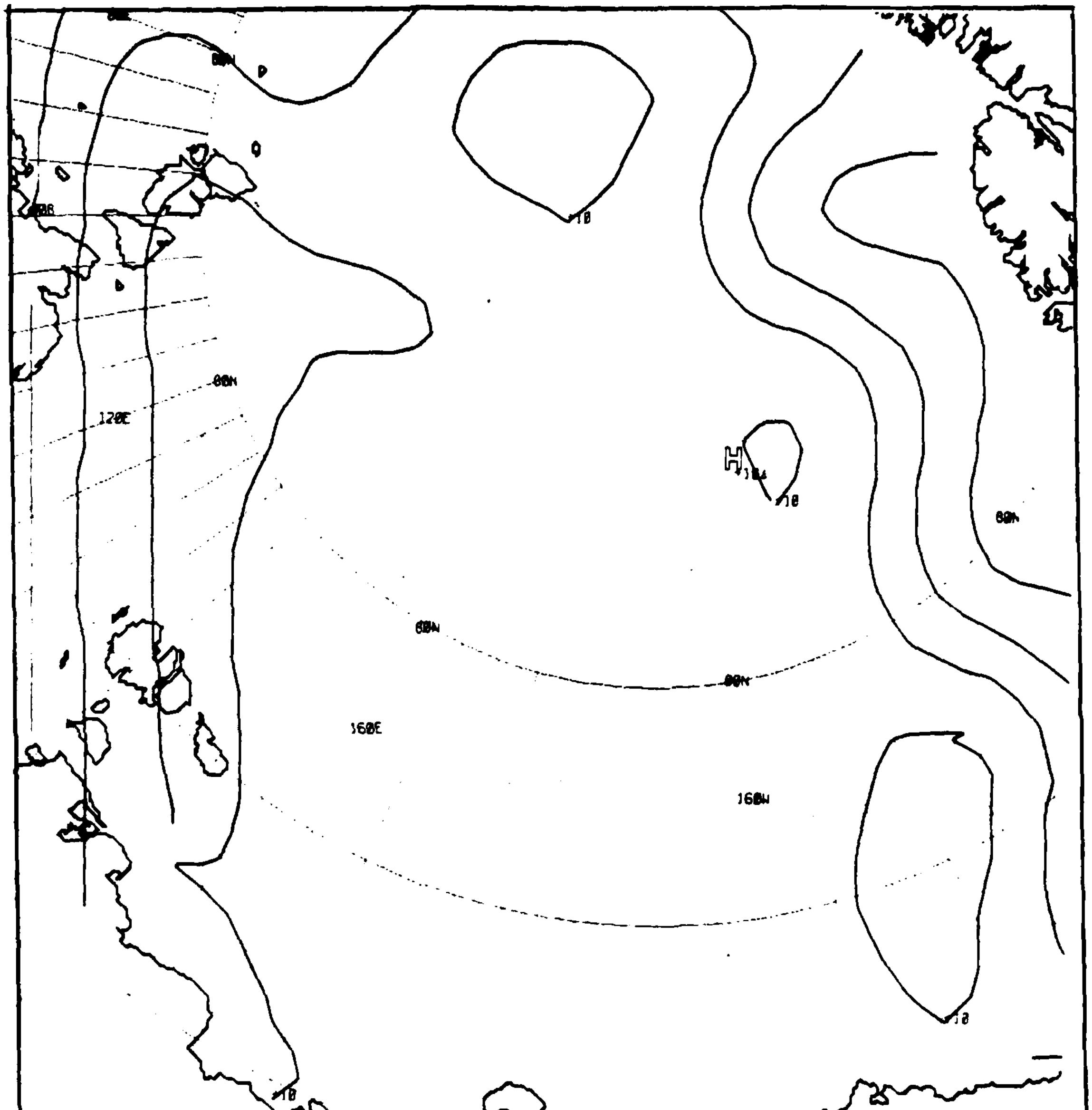


80N
80N
120E
80N
80N
80N
160E
160W
AVERAGE OPEN WATER GROWTH FOR JUNE
CONTOUR INTERVAL IS CM
LABELS ARE CM OF GROWTH PER DAY
FLEET NUMERICAL OCEANOGRAPHY

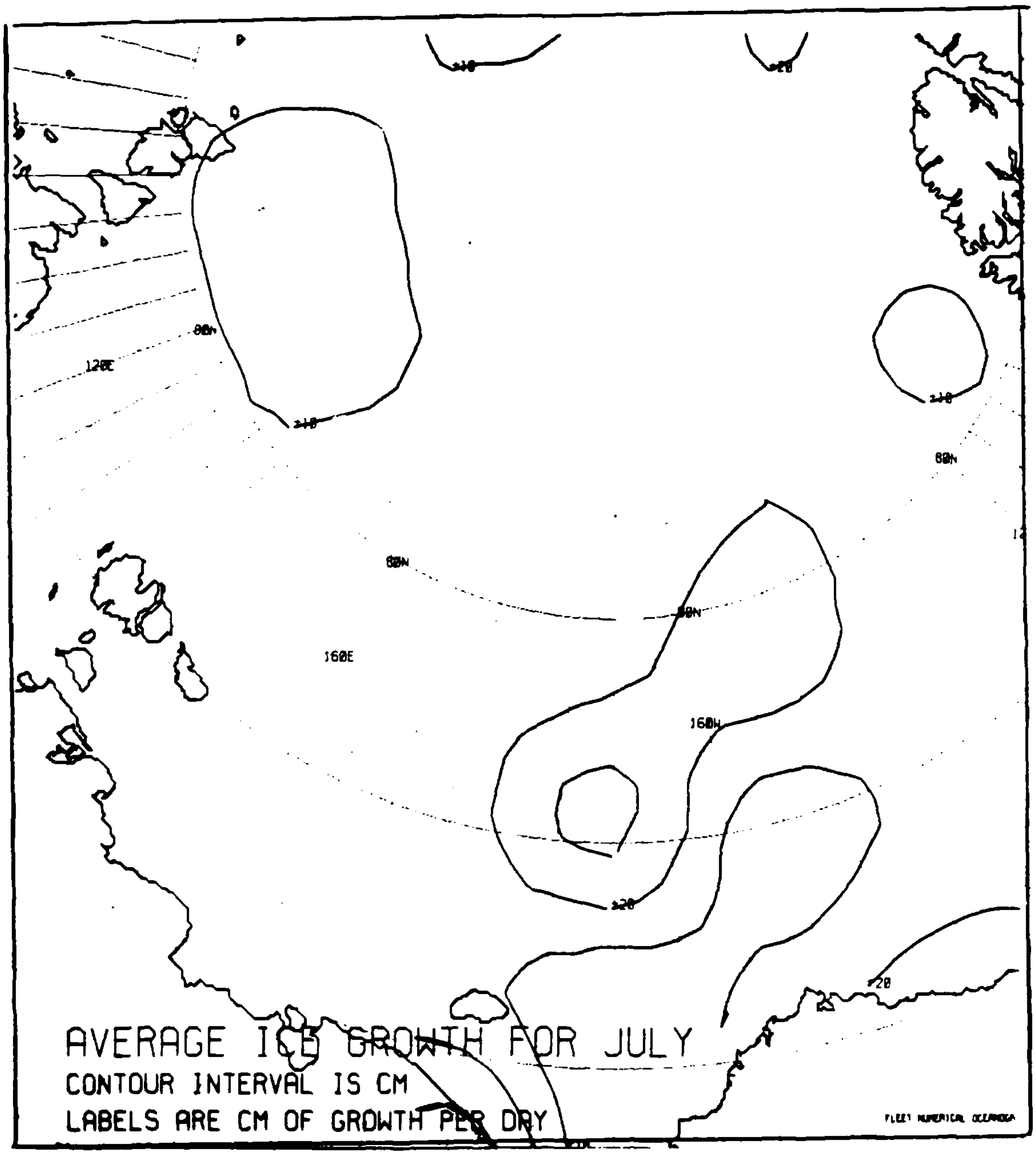

AVERAGE WIND DATA FOR JULY
FLEET NUMERICAL

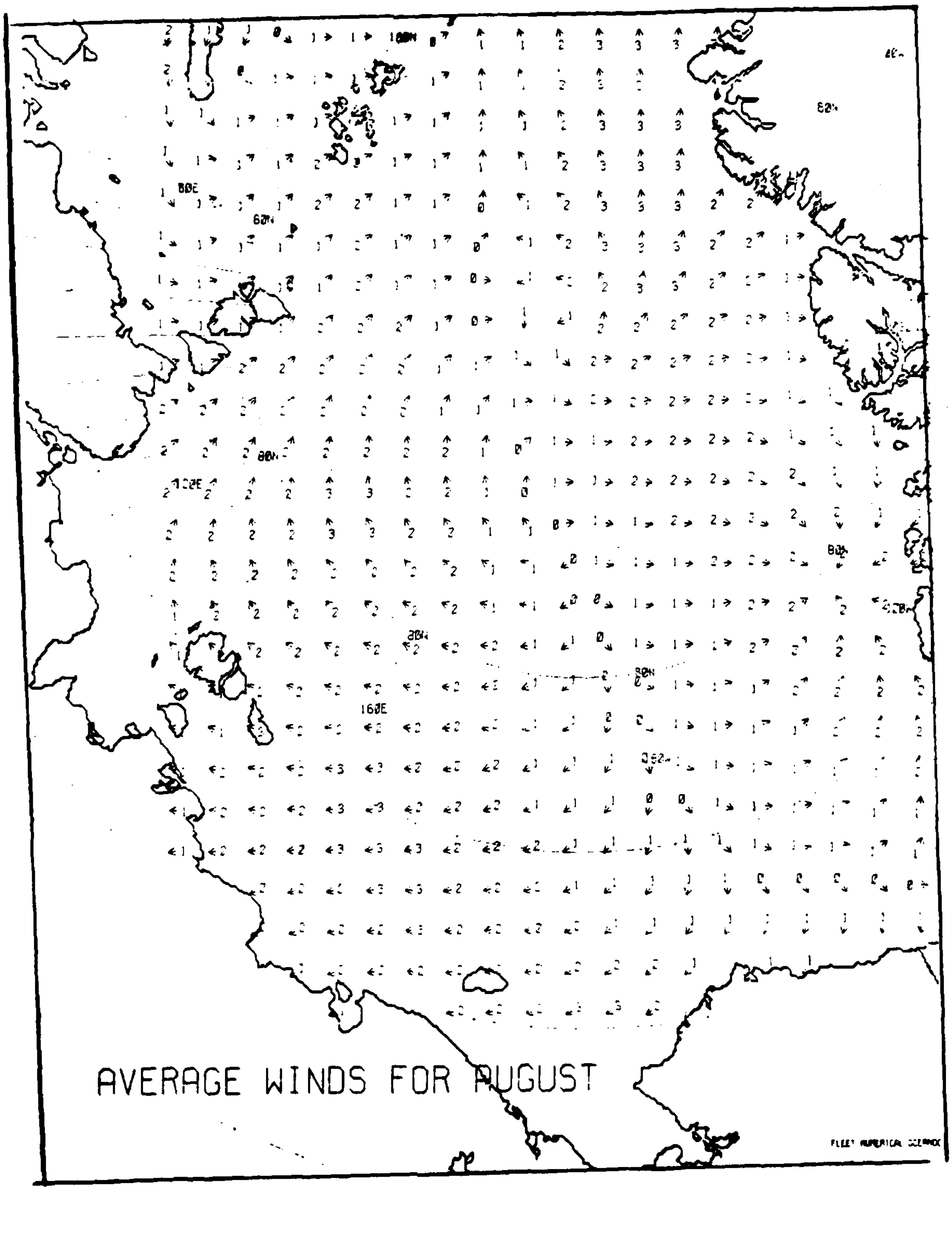

MEAN JULY ICE DRIFT
LABEL DIVIDED BY 100 GIVES NM OF ICE MOVEMENT IN 24 HRS


AVERAGE JULY ICE THICKNESS
CONTOUR INTERVAL IS 10 CM
LABEL TIMES 10 GIVES CM OF ICE IN GRID CELL
80N
120E
160E
160W

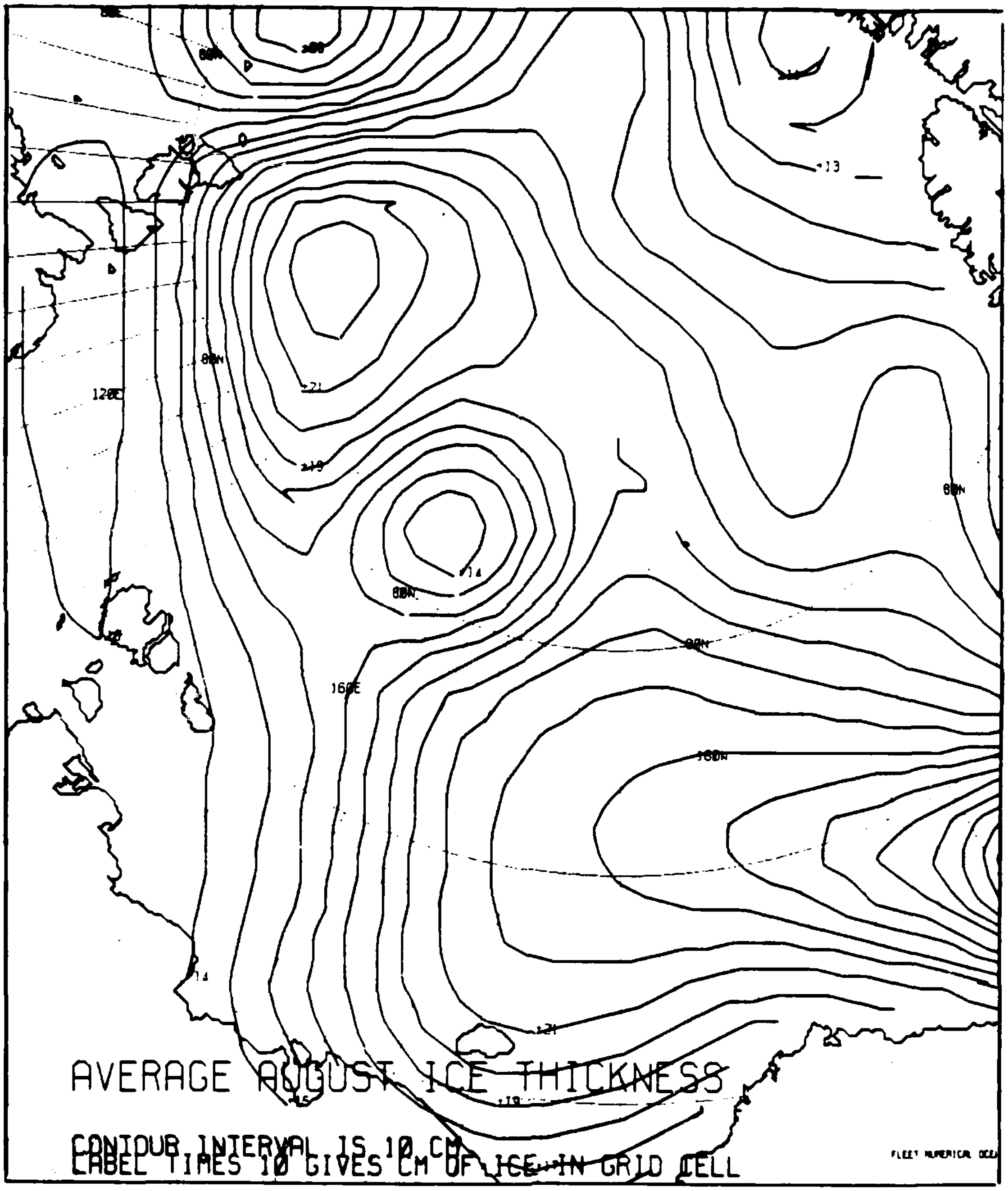


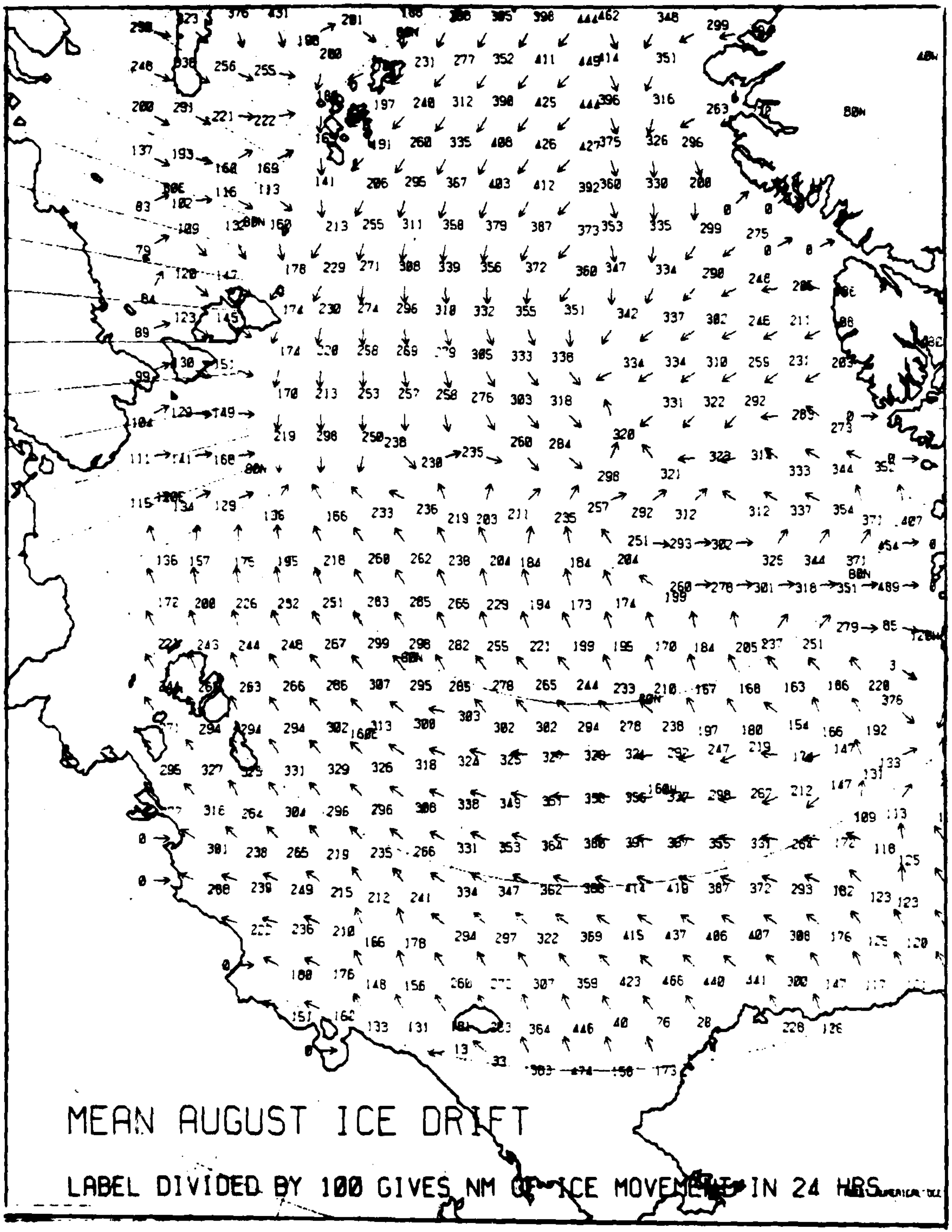
AVERAGE JULY ICE CONCENTRATION
CONTOUR INTERVAL IS 10 PERCENT INCREMENT OF GRID COVERERAGE
LABELS ARE PERCENT OF GRID CELL COVERED BY THICK ICE DIVIDEE


AVERAGE ICE GROWTH FOR JULY
CONTOUR INTERVAL IS CM
LABELS ARE CM OF GROWTH PER DAY
80N
120E
160E
160W
FLEET NUMERICAL OCEANOGA



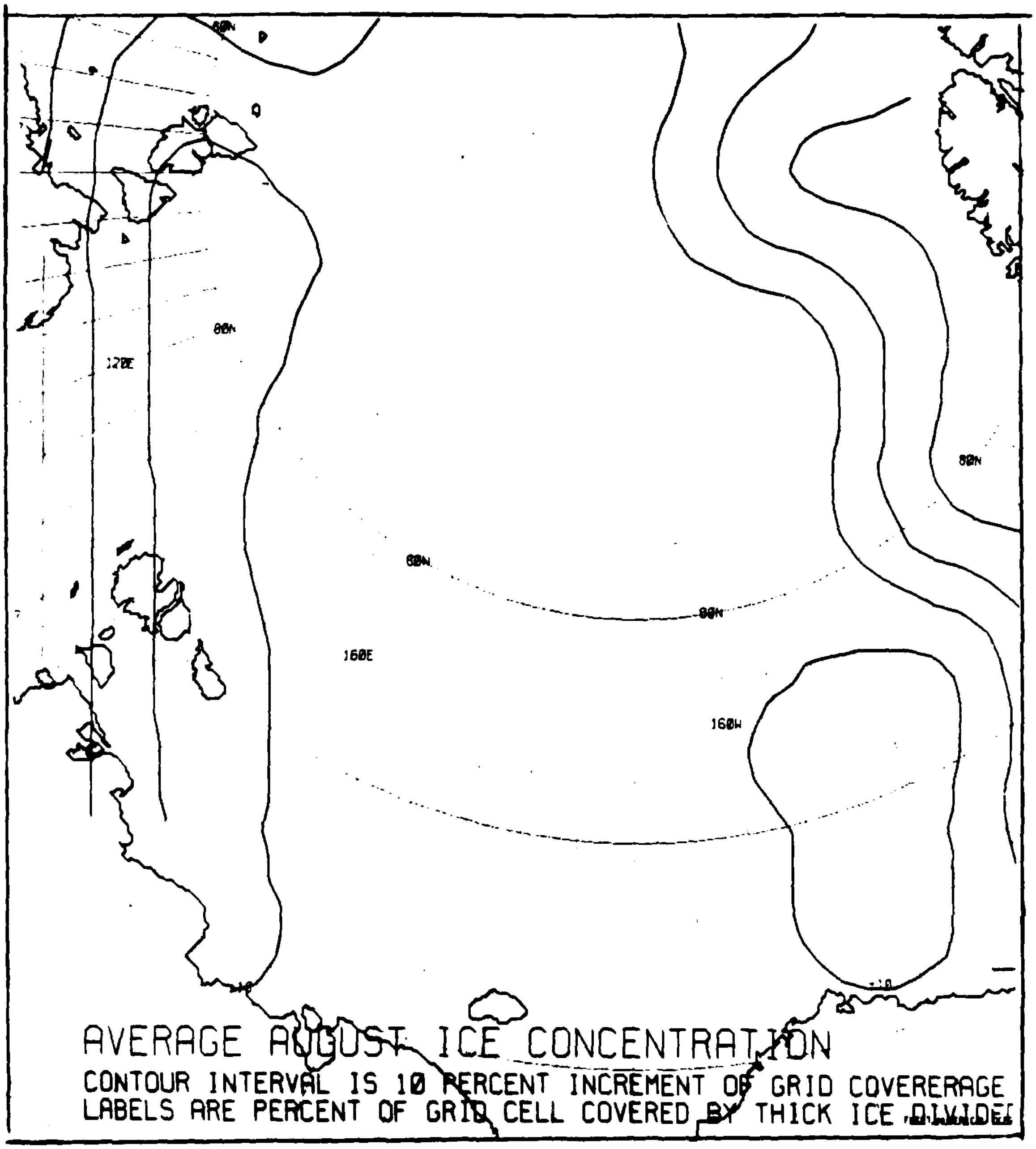
AVERAGE WINDS FOR AUGUST
FLEET NUMERICAL OCEANOGRAPHY


AVERAGE AUGUST ICE THICKNESS
CONTOUR INTERVAL IS 10 CM
LABEL TIMES 10 GIVES CM OF ICE IN GRID CELL
120E
160E
180W
80N

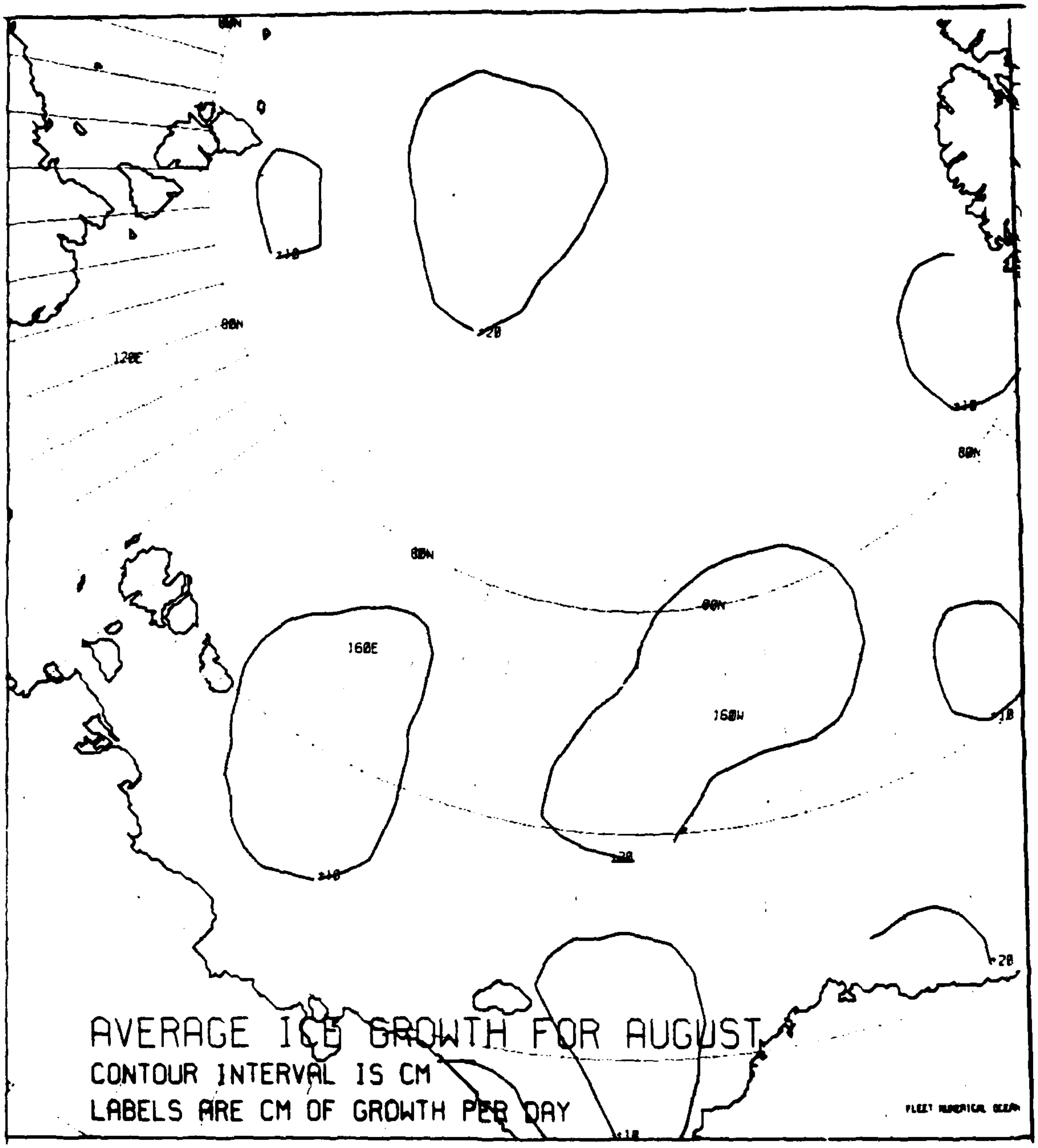


MEAN AUGUST ICE DRIFT

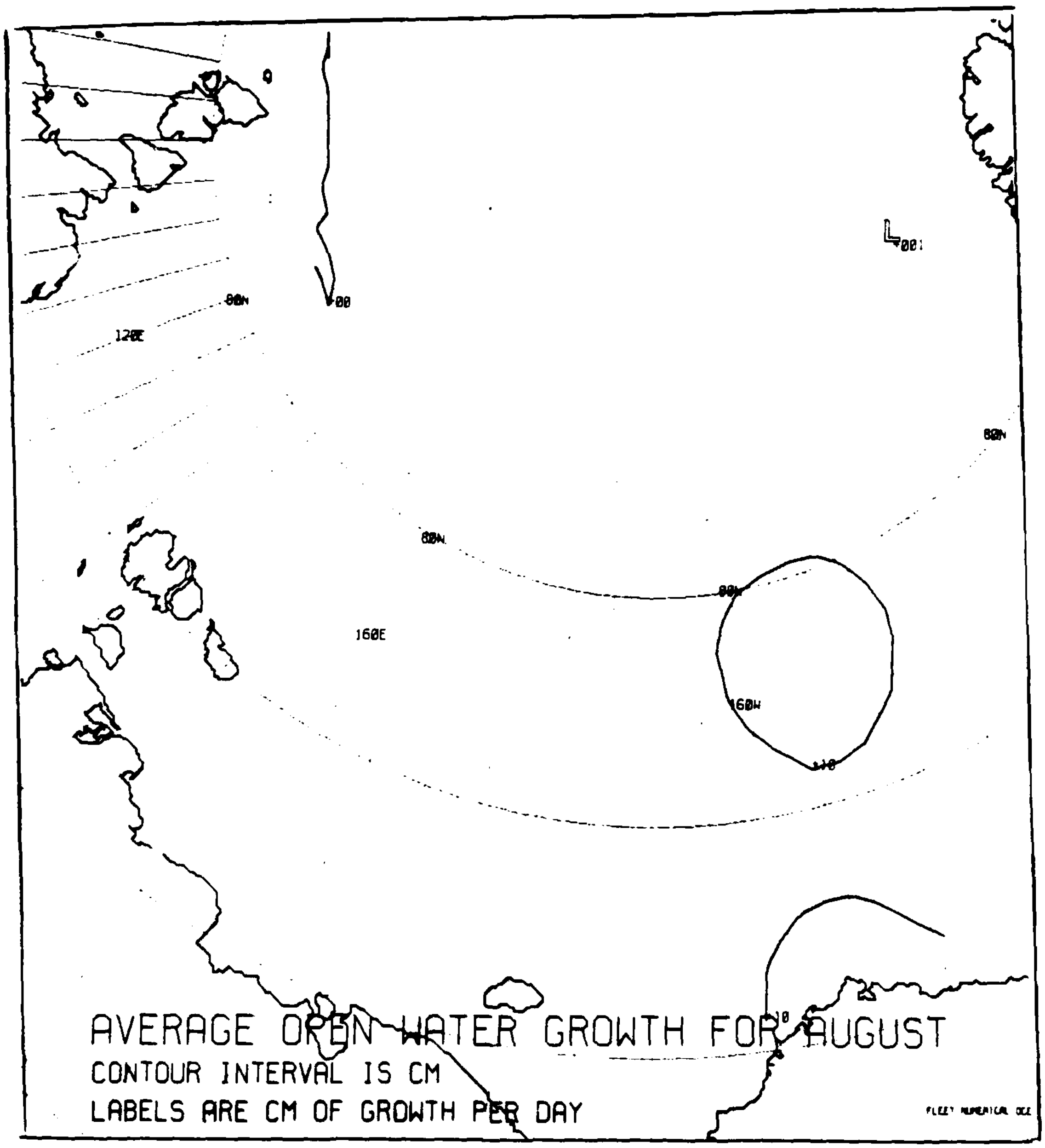
LABEL DIVIDED BY 100 GIVES NM OF ICE MOVEMENT IN 24 HRS

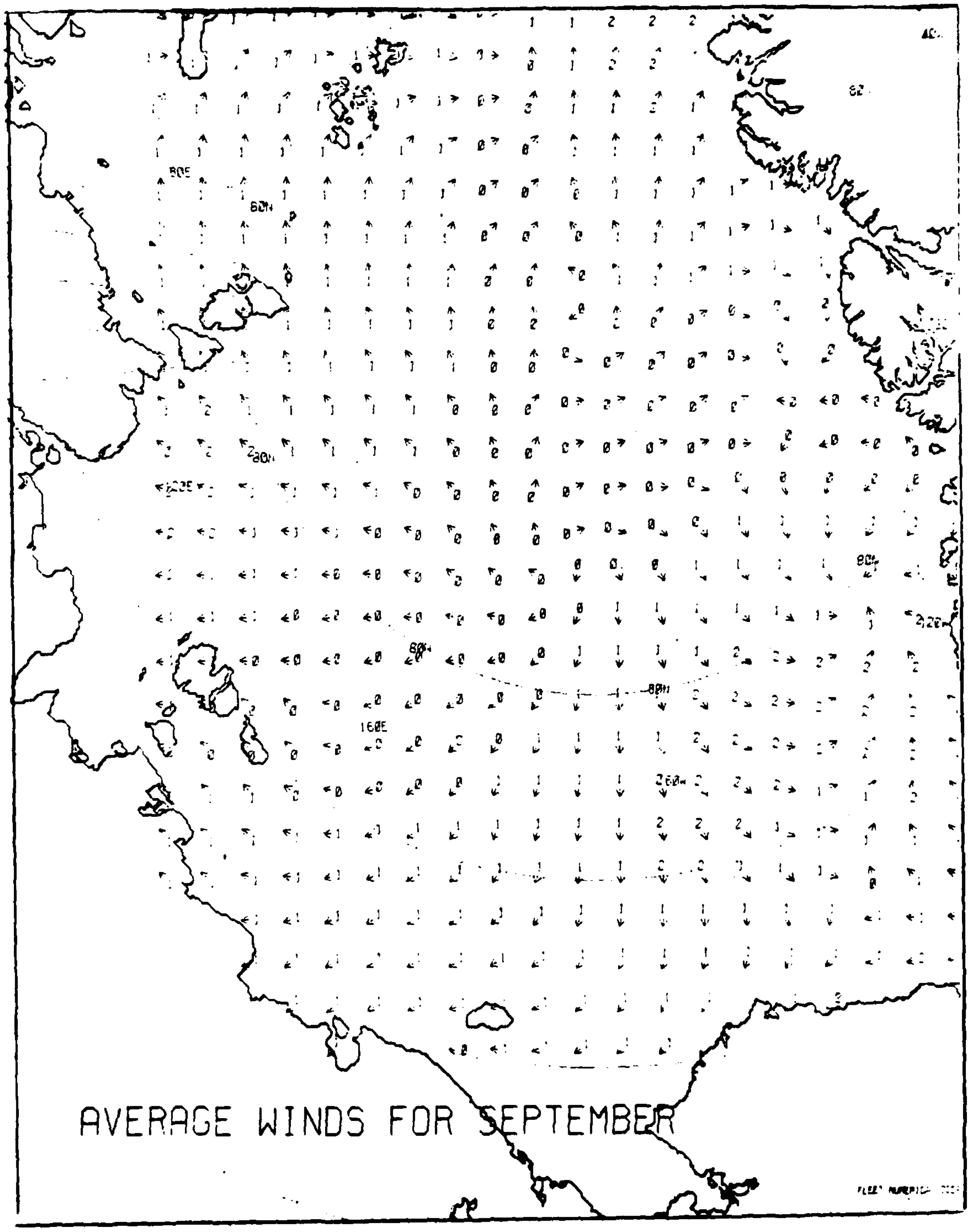


AVERAGE AUGUST ICE CONCENTRATION
CONTOUR INTERVAL IS 10 PERCENT INCREMENT OF GRID COVERERAGE
LABELS ARE PERCENT OF GRID CELL COVERED BY THICK ICE DIVIDEI

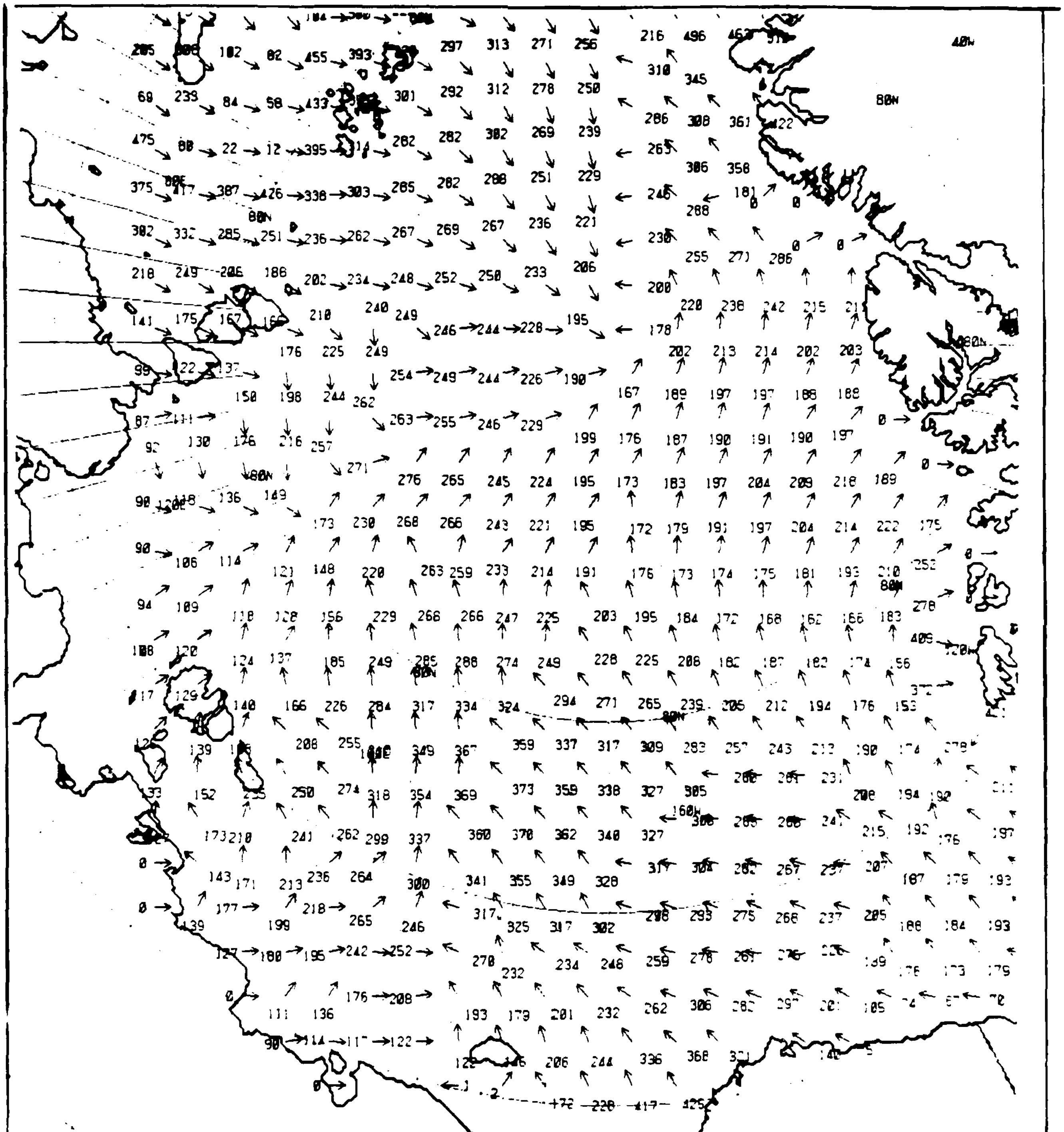


AVERAGE ICE GROWTH FOR AUGUST
CONTOUR INTERVAL IS CM
LABELS ARE CM OF GROWTH PER DAY


80N
00
120E
80N
80N
80N
160E
160W
10
AVERAGE OPEN WATER GROWTH FOR AUGUST
CONTOUR INTERVAL IS CM
LABELS ARE CM OF GROWTH PER DAY
FLEET NUMERICAL OCE

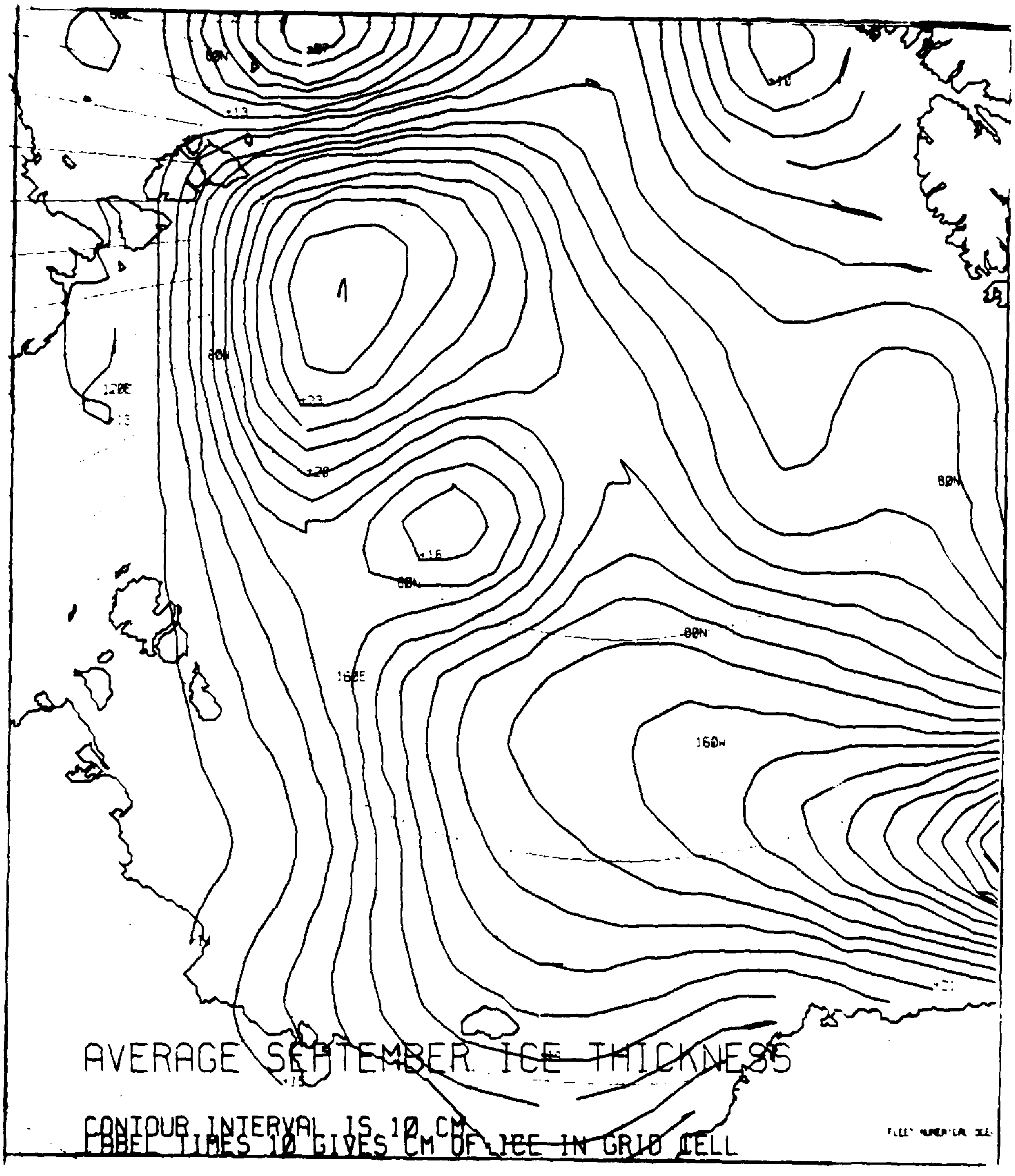


AVERAGE WINDS FOR SEPTEMBER



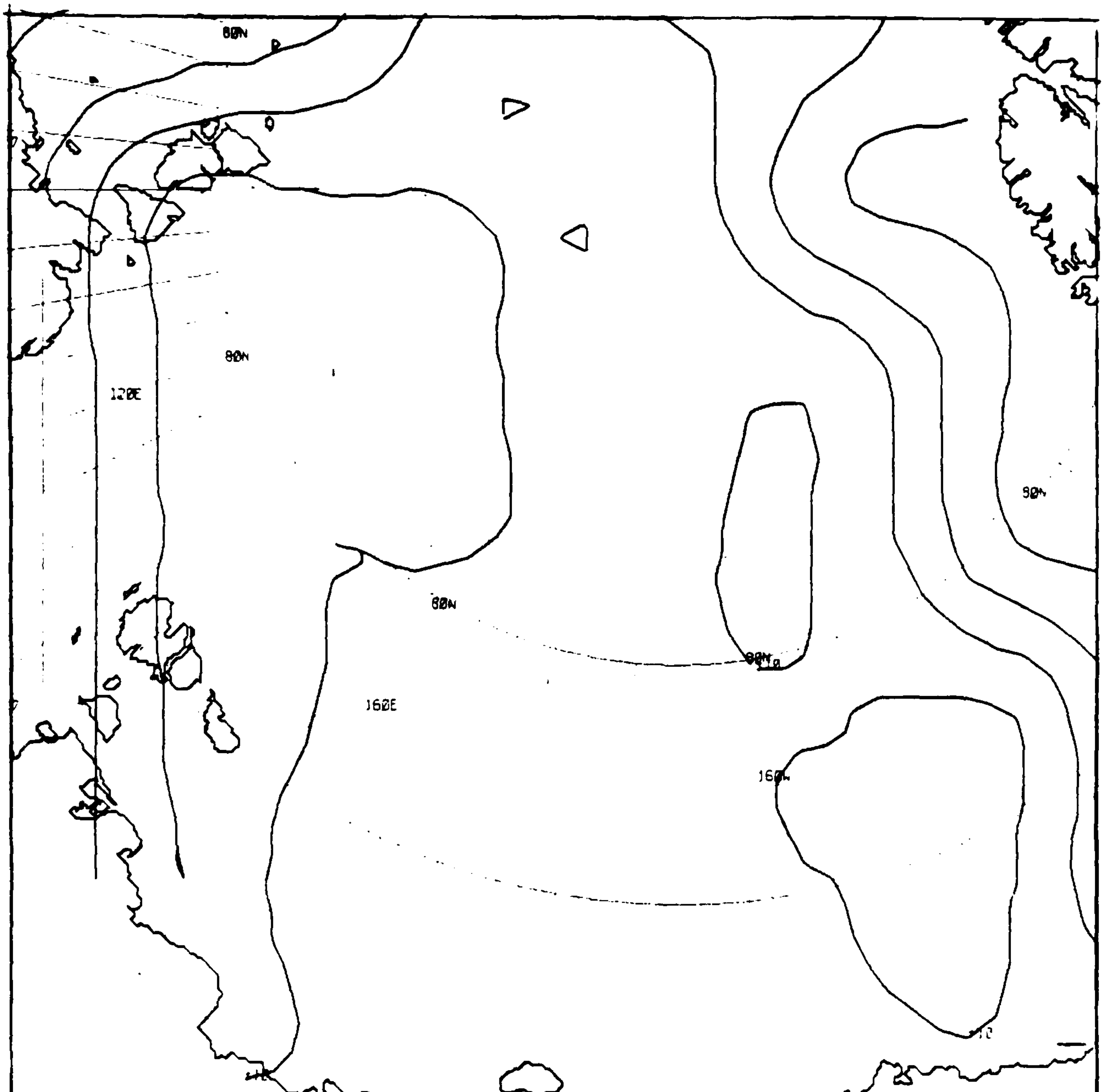
MEAN SEPTEMBER ICE DRIFT

LABEL DIVIDED BY 100 GIVES NM OF ICE MOVEMENT IN 24 HRS

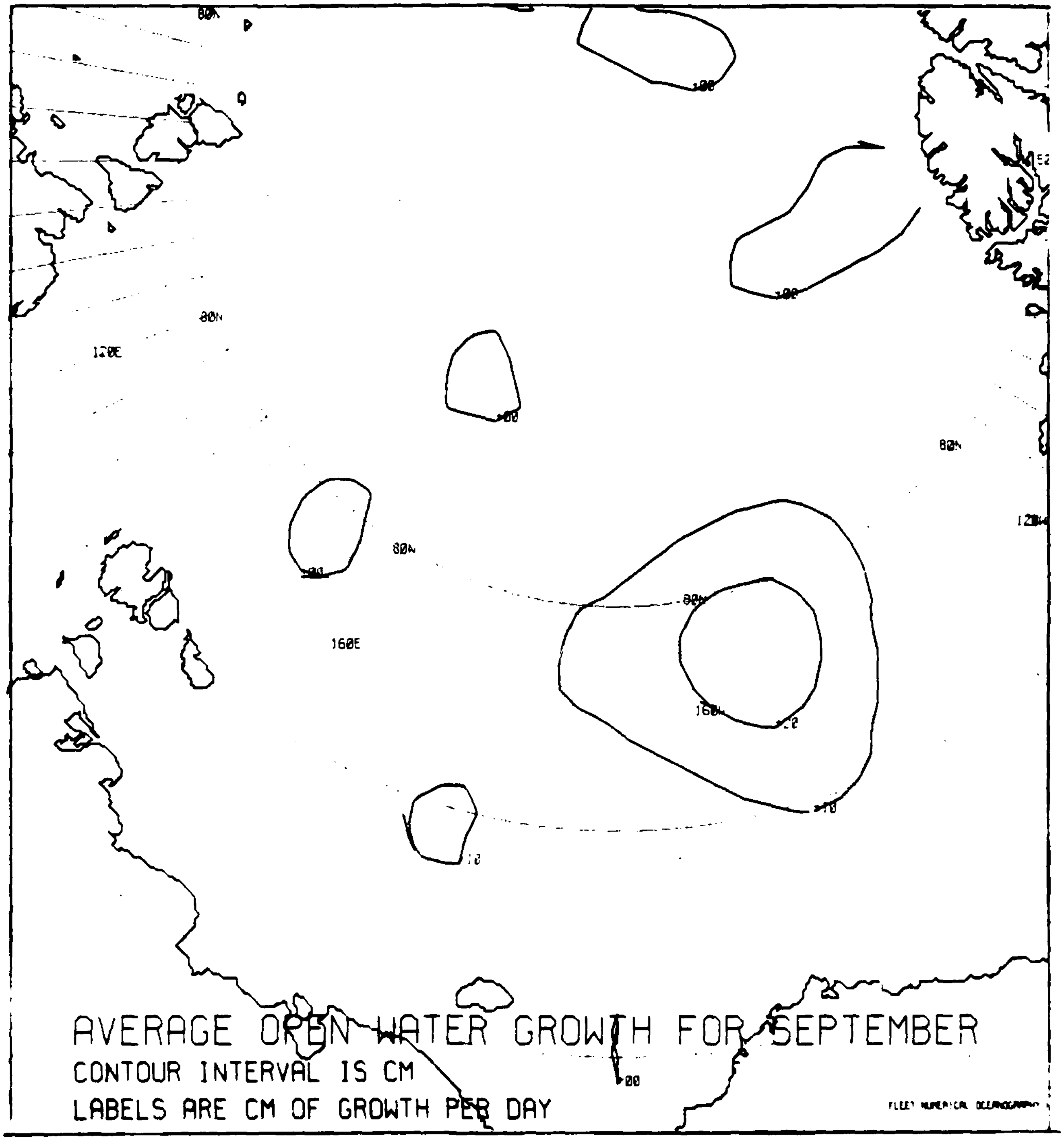


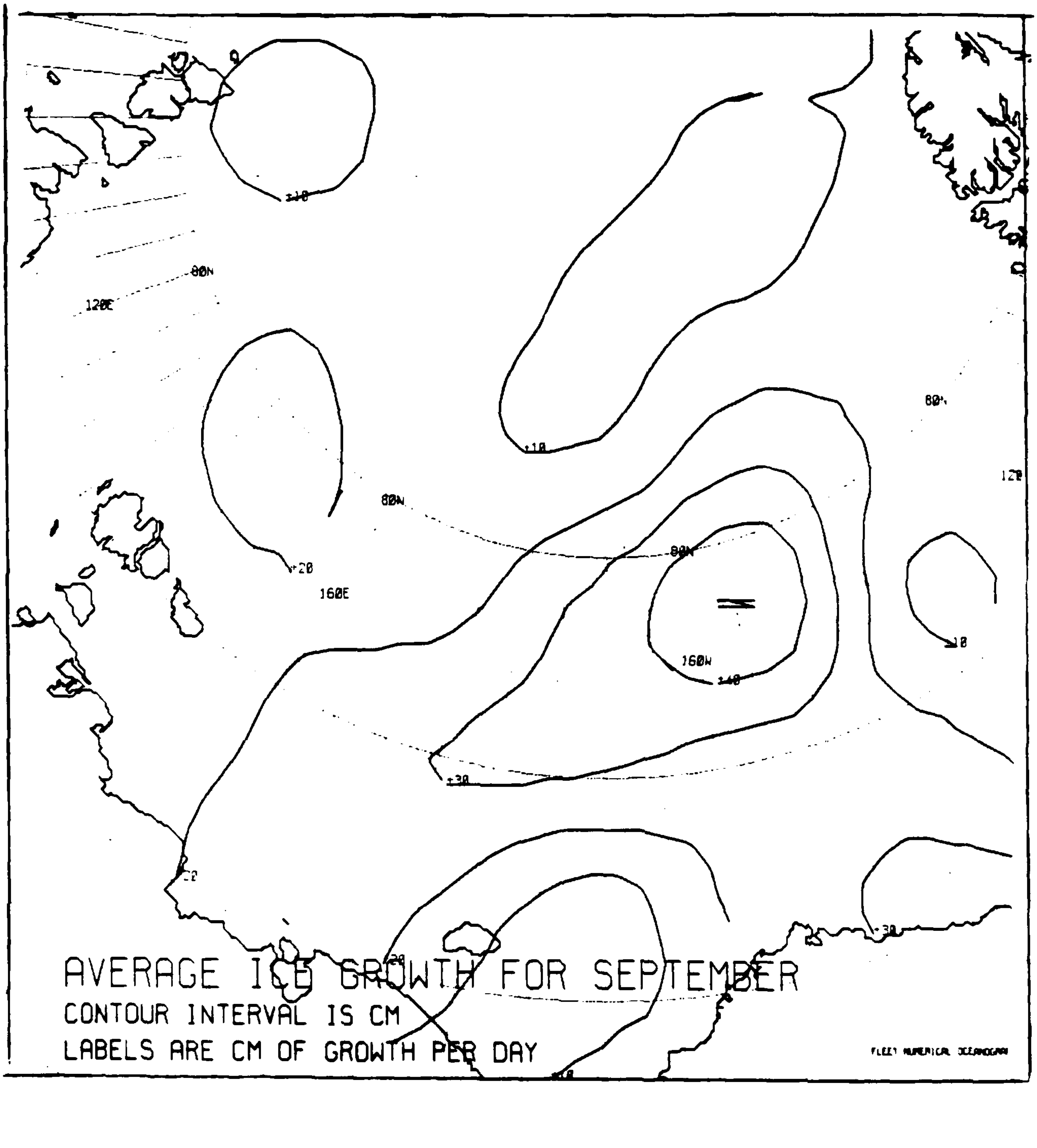
AVERAGE SEPTEMBER ICE THICKNESS

CONTOUR INTERVAL IS 10 CM
LABEL TIMES 10 GIVES CM OF ICE IN GRID CELL

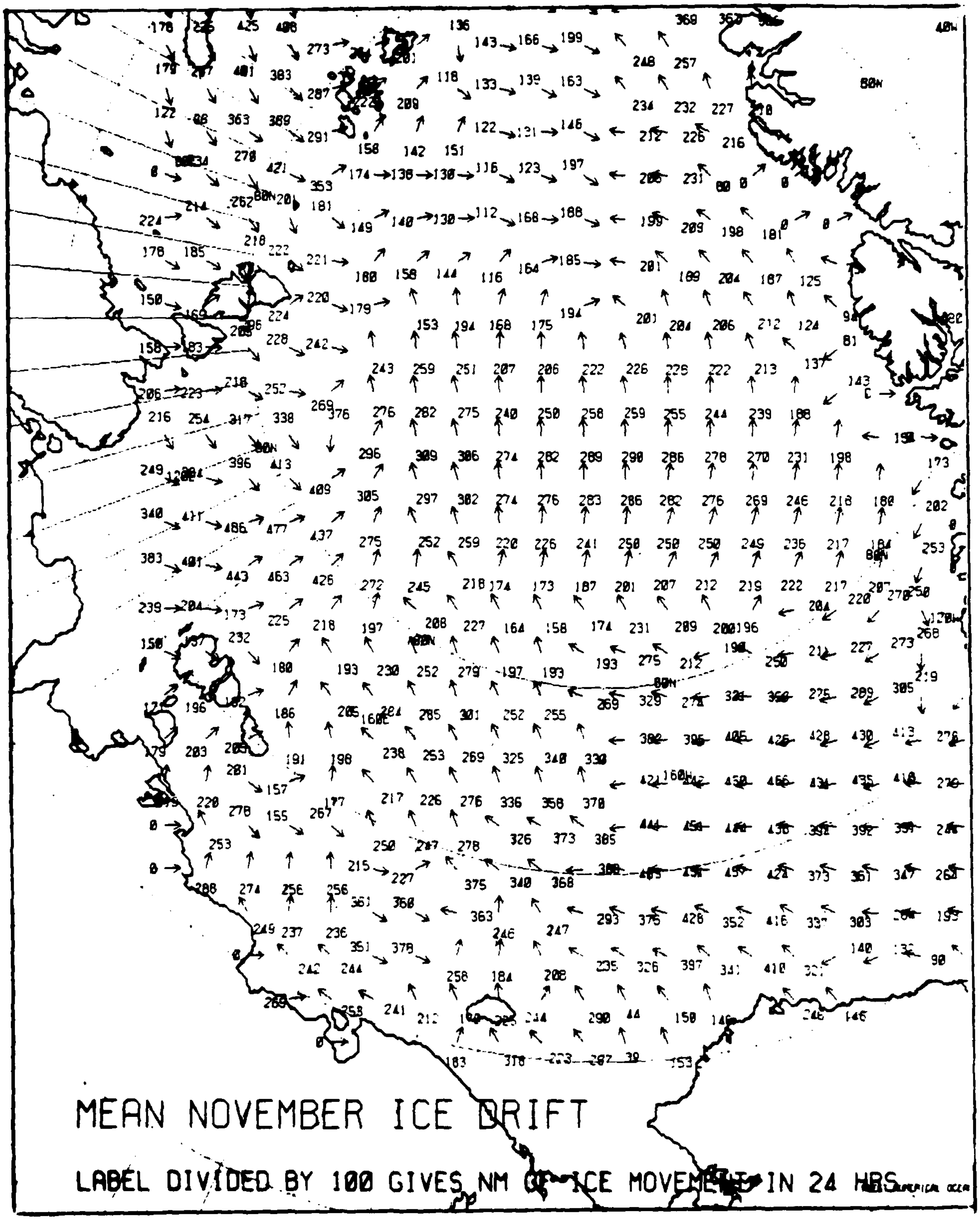


AVERAGE SEPTEMBER ICE CONCENTRATION
CONTOUR INTERVAL IS 10 PERCENT INCREMENT OF GRID COVERERAGE
LABELS ARE PERCENT OF GRID CELL COVERED BY THICK ICE DIVIDED


AVERAGE OPEN WATER GROWTH FOR SEPTEMBER
CONTOUR INTERVAL IS CM
LABELS ARE CM OF GROWTH PER DAY
FLEET NUMERICAL OCEANOGRAPHY
80N
120E
160E
160W
120W

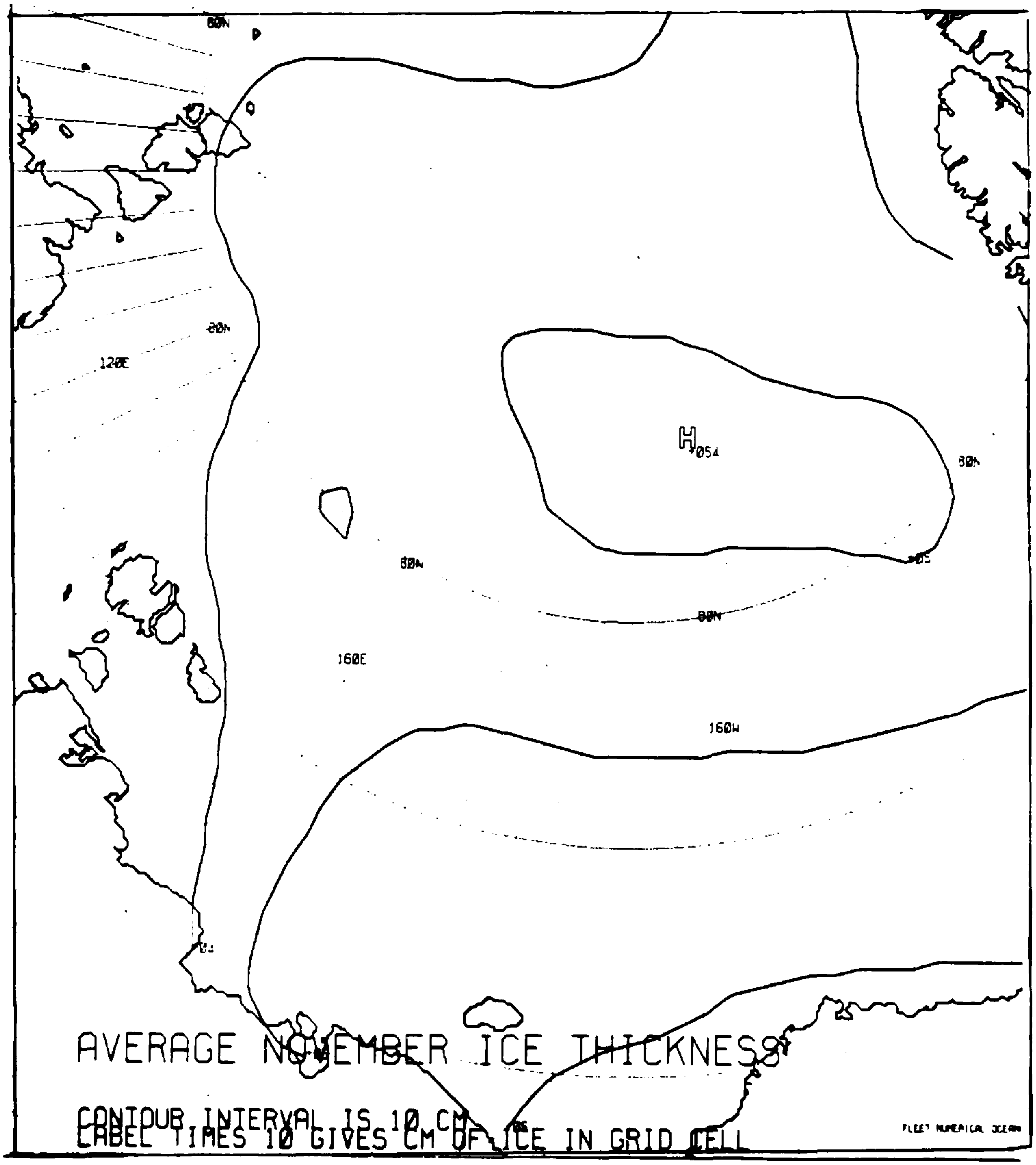


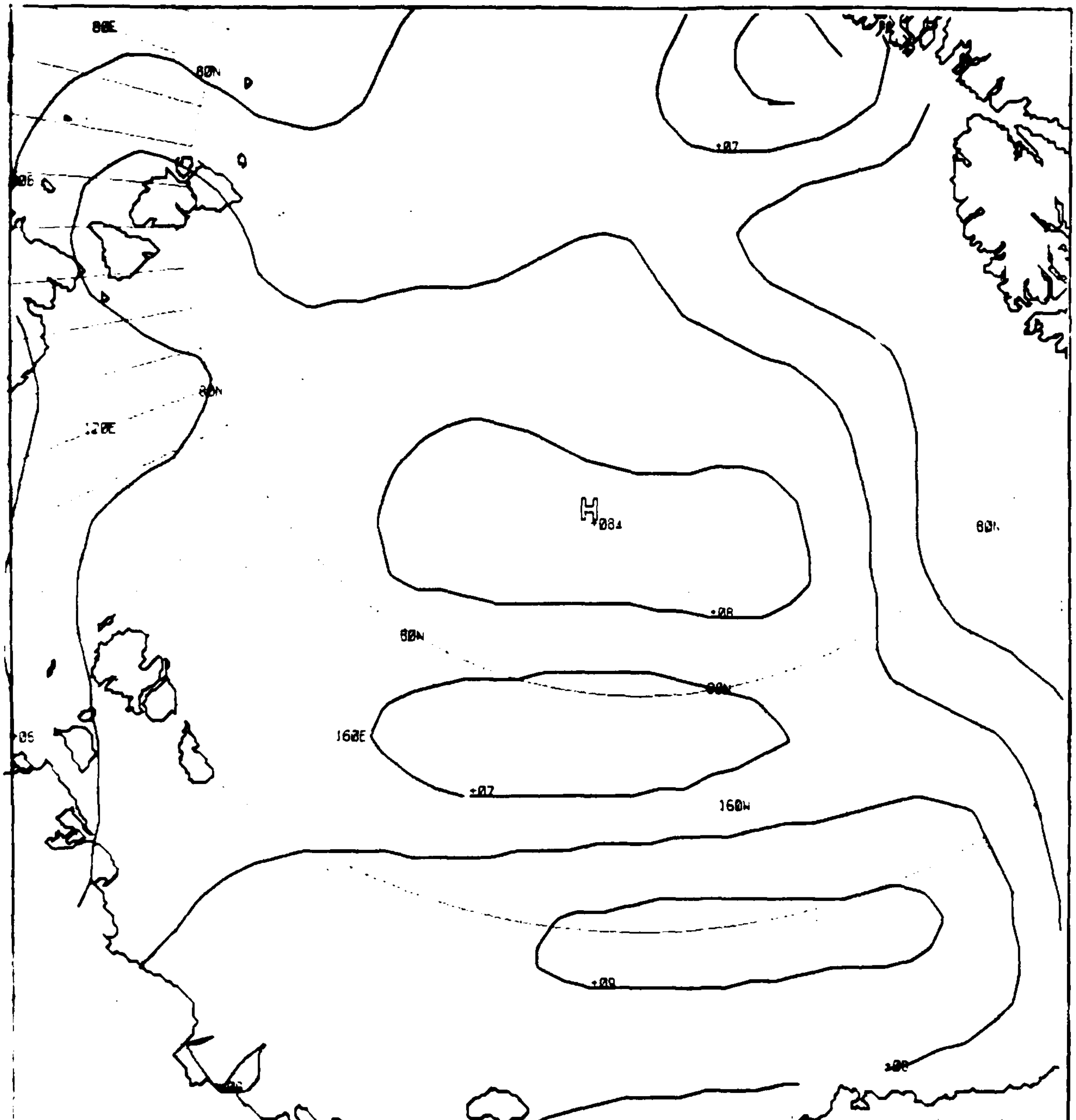
AVERAGE ICE GROWTH FOR SEPTEMBER
CONTOUR INTERVAL IS CM
LABELS ARE CM OF GROWTH PER DAY



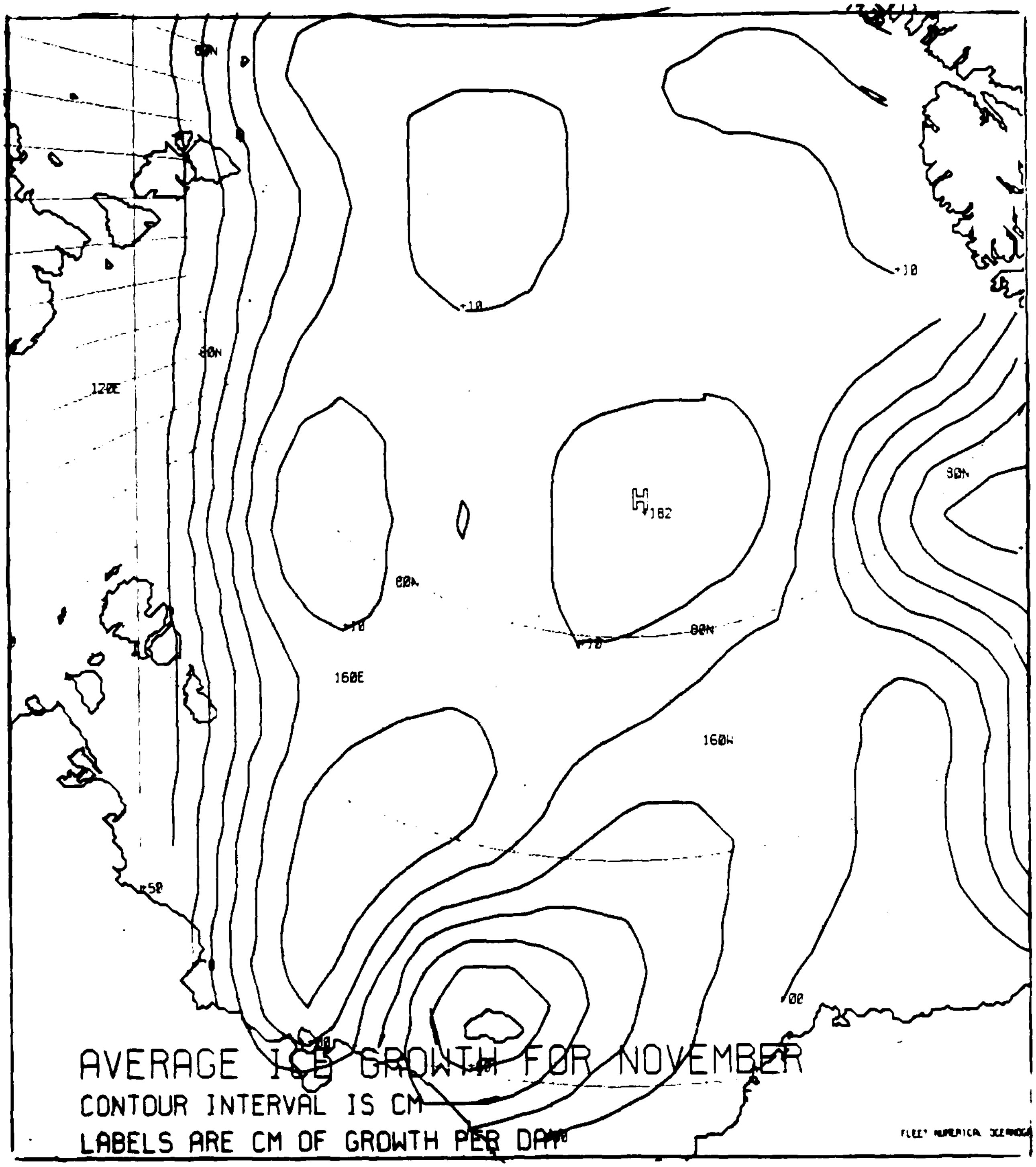
MEAN NOVEMBER ICE DRIFT

LABEL DIVIDED BY 100 GIVES NM OF ICE MOVEMENT IN 24 HRS

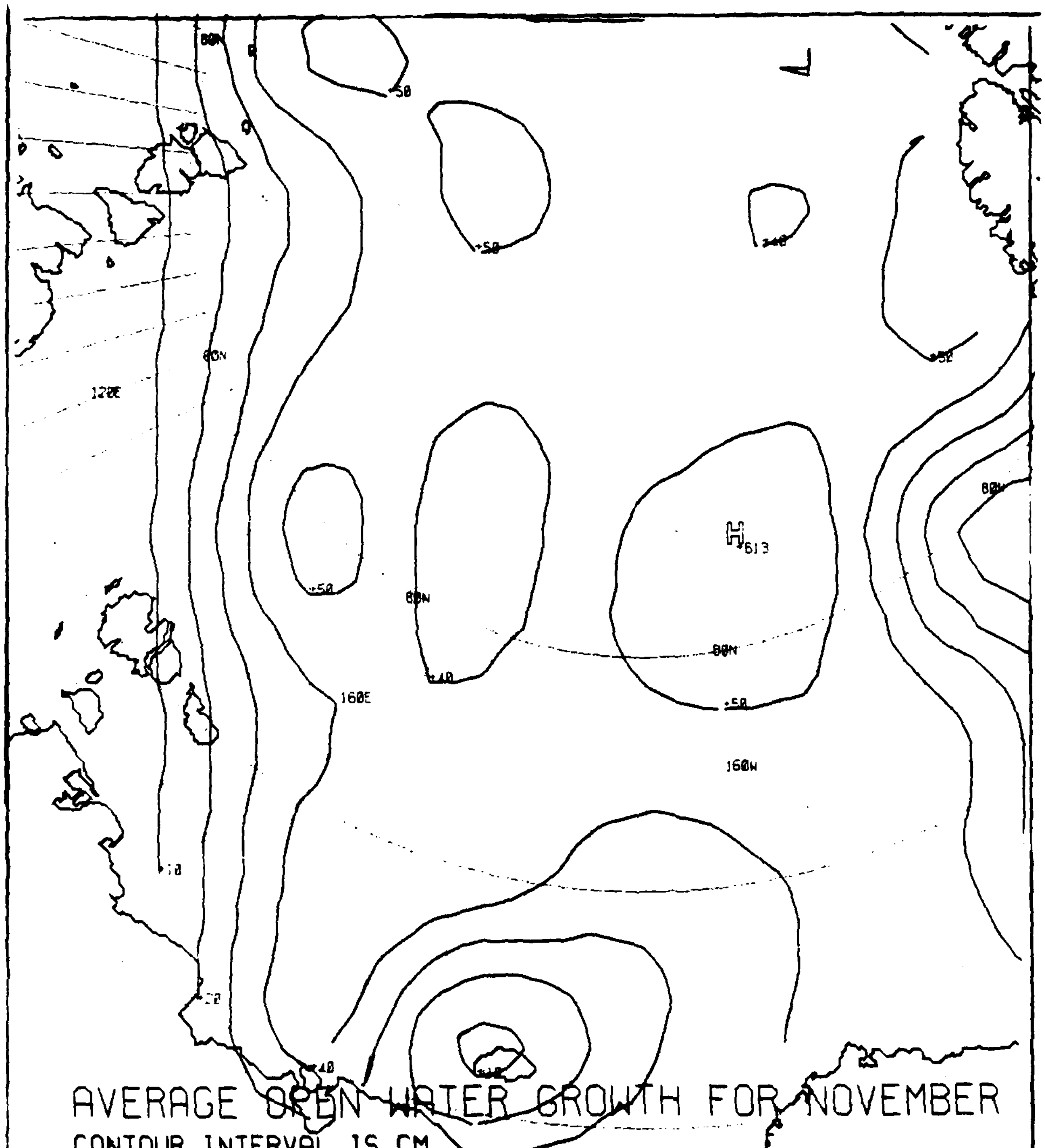

80N
80N
120E
H
054
80N
80N
80N
160E
160W
05
FLEET NUMERICAL OCEAN
AVERAGE NOVEMBER ICE THICKNESS
CONTOUR INTERVAL IS 10 CM
LABEL TIMES 10 GIVES CM OF ICE IN GRID CELL



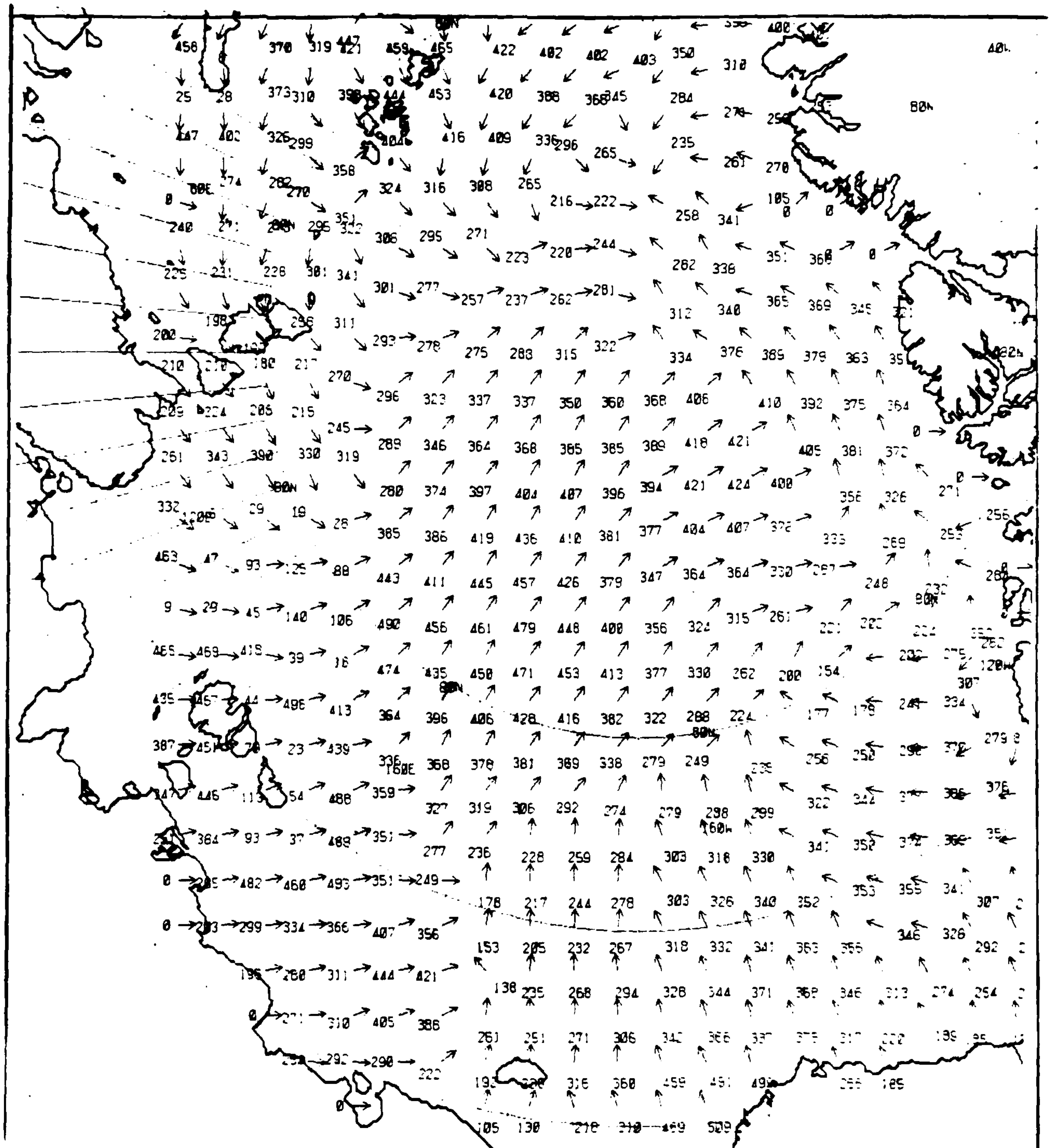
AVERAGE NOVEMBER ICE CONCENTRATION
CONTOUR INTERVAL IS 10 PERCENT INCREMENT OF GRID COVERERAGE
LABELS ARE PERCENT OF GRID CELL COVERED BY THICK ICE DIVIDED



AVERAGE ICE GROWTH FOR NOVEMBER
CONTOUR INTERVAL IS CM
LABELS ARE CM OF GROWTH PER DAY

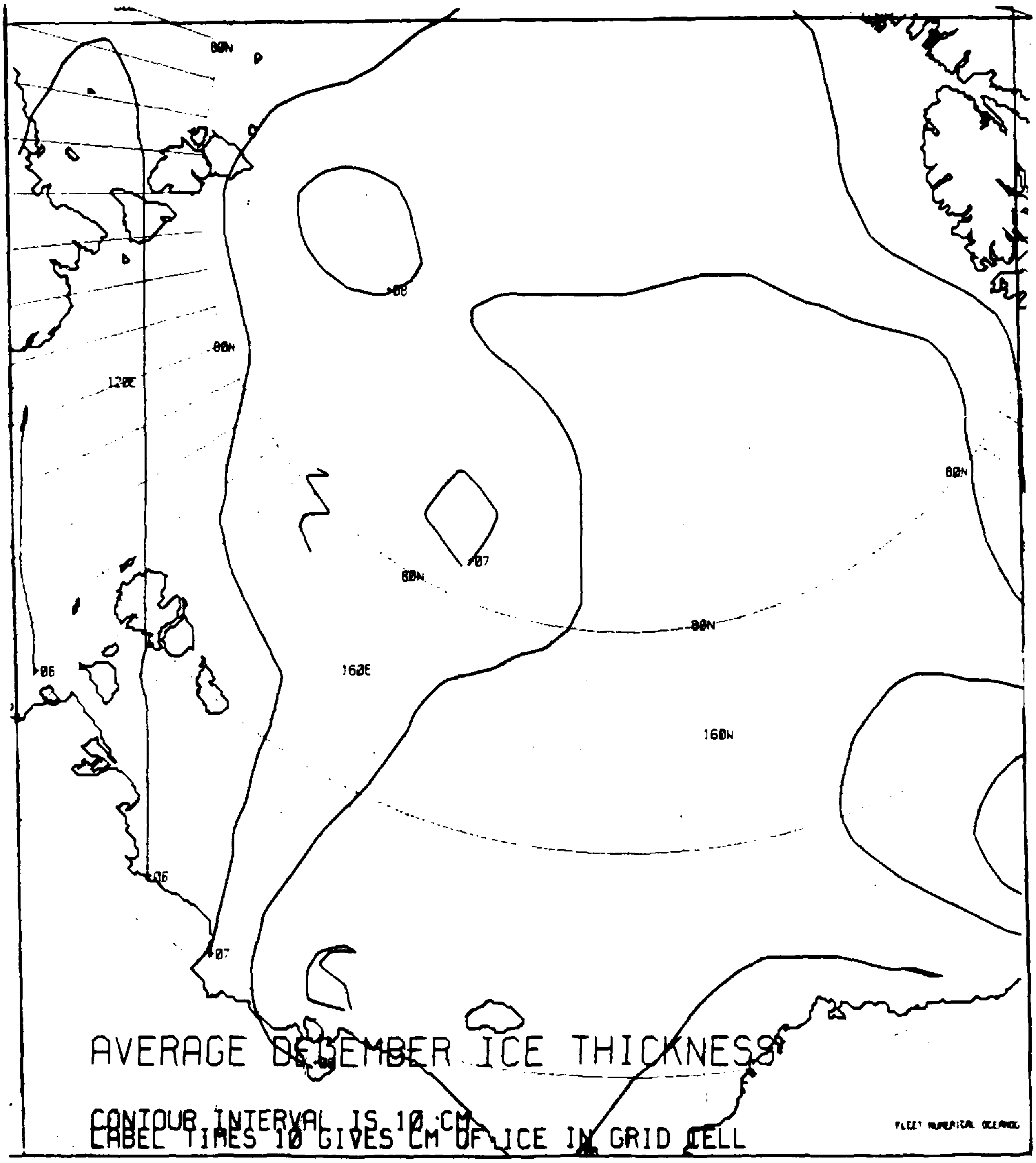


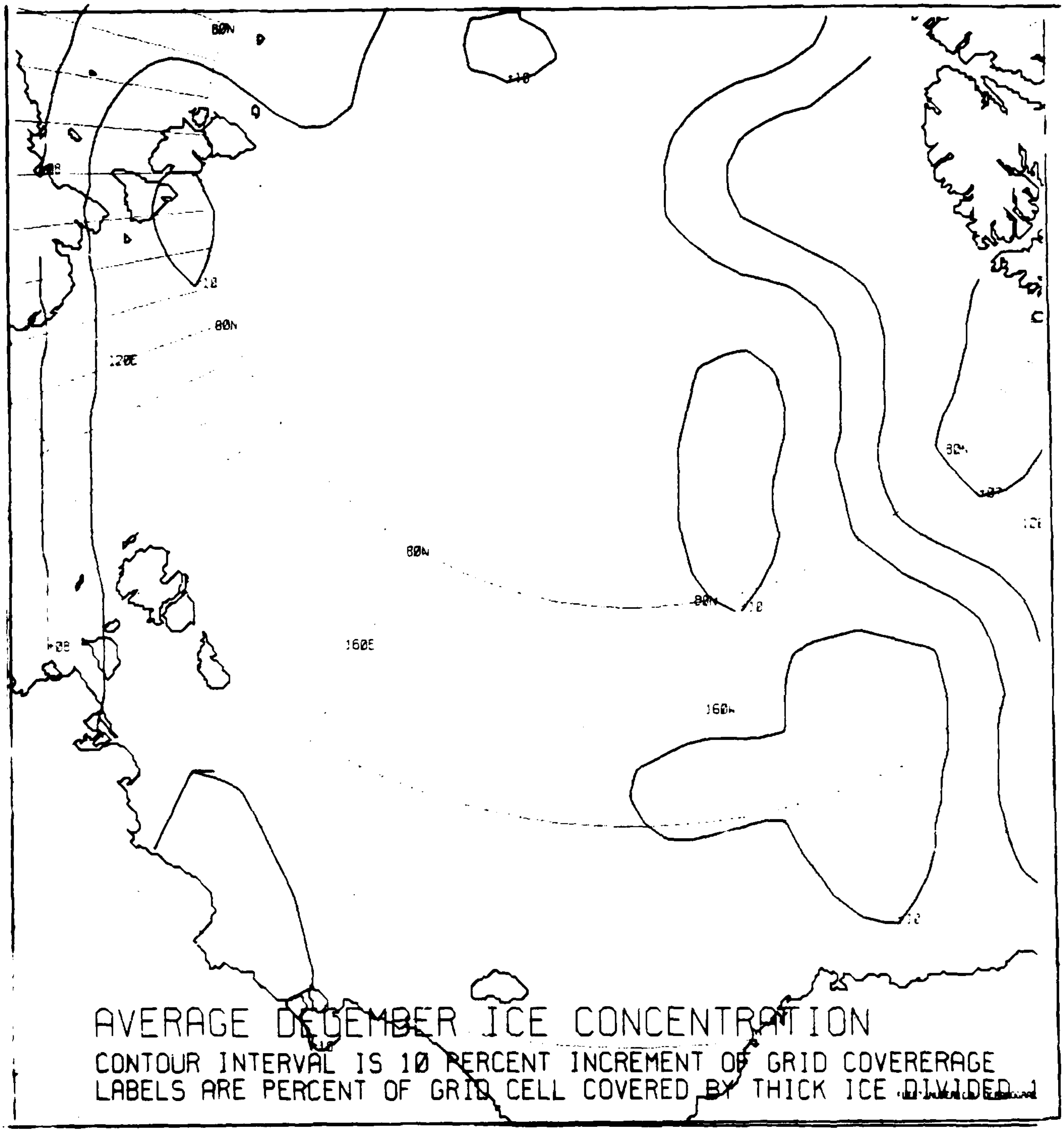
AVERAGE OPEN WATER GROWTH FOR NOVEMBER
CONTOUR INTERVAL IS CM
LABELS ARE CM OF GROWTH PER DAY
FLEET NUMERICAL
120E
160E
160W
80N
80W
H
613
+50
+40
+10
+20
+30

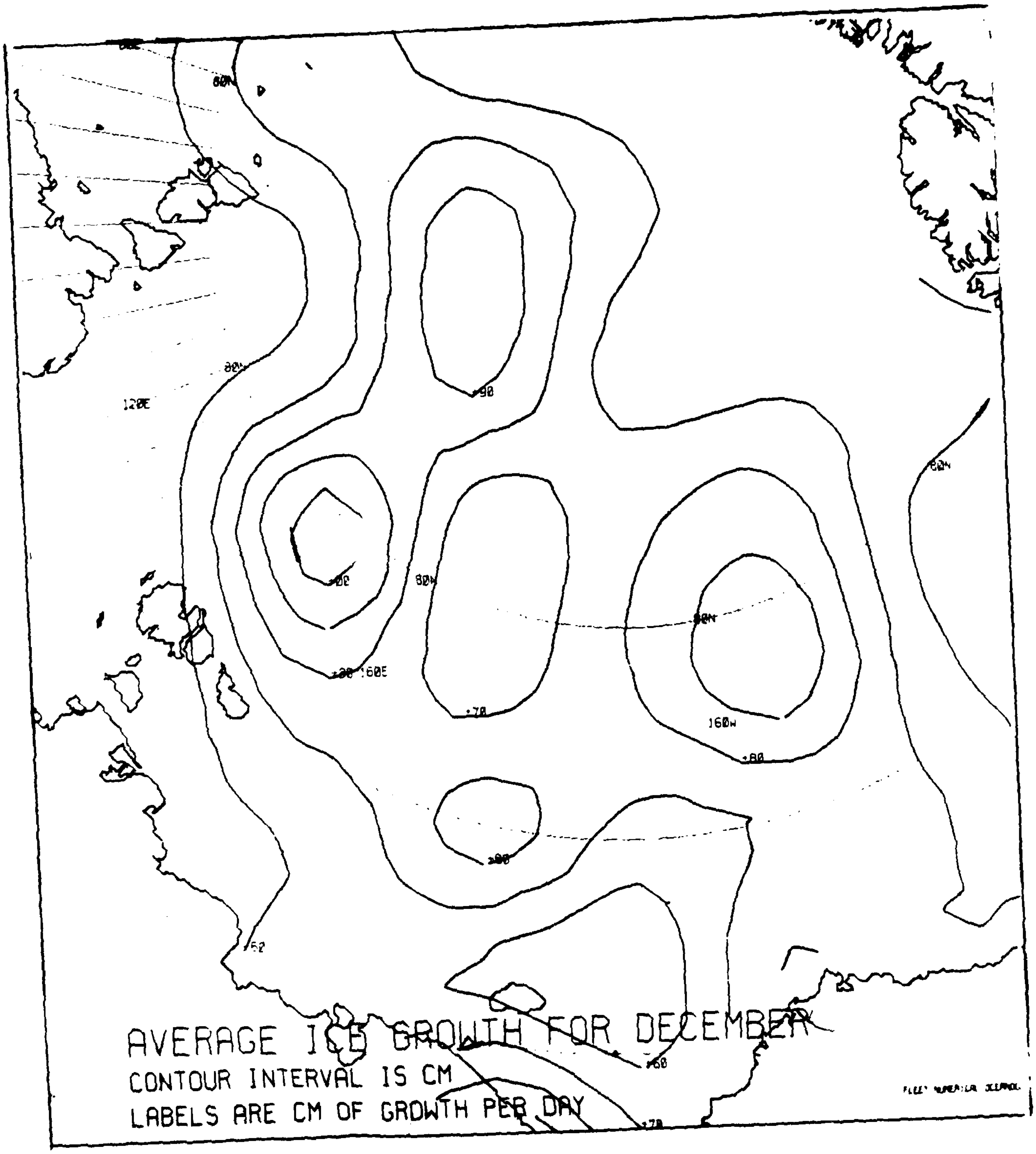


MEAN DECEMBER ICE DRIFT

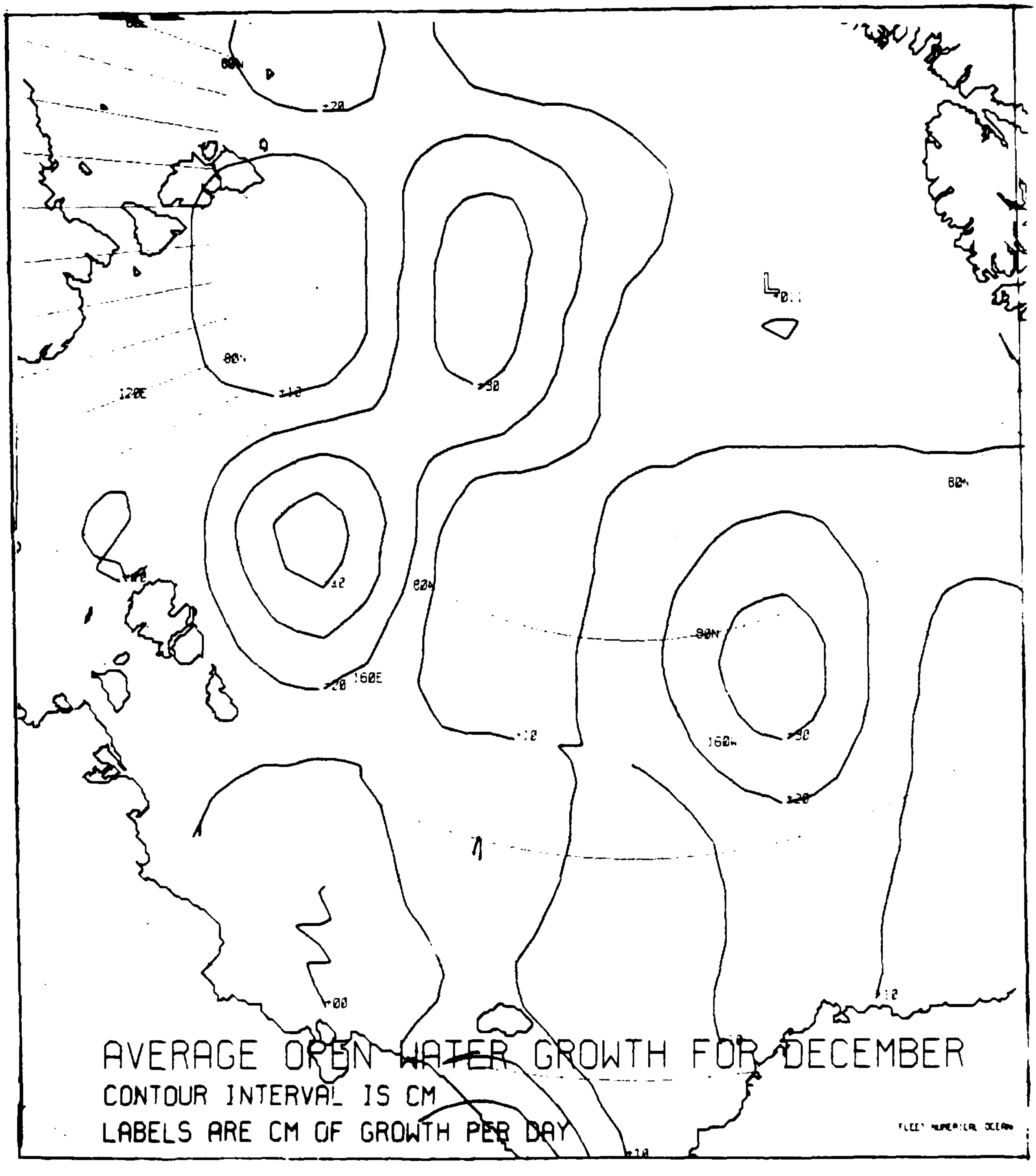
LABEL DIVIDED BY 100 GIVES NM OF ICE MOVEMENT IN 24 HRS


80N
80N
120E
08
07
80N
80N
06
160E
160W
06
07
AVERAGE DECEMBER ICE THICKNESS
CONTOUR INTERVAL IS 10 CM
LABEL TIMES 10 GIVES CM OF ICE IN GRID CELL
FLEET NUMERICAL OCEANOG


AVERAGE DECEMBER ICE CONCENTRATION
CONTOUR INTERVAL IS 10 PERCENT INCREMENT OF GRID COVERERAGE
LABELS ARE PERCENT OF GRID CELL COVERED BY THICK ICE DIVIDED 1
80N
120E
160E
160W

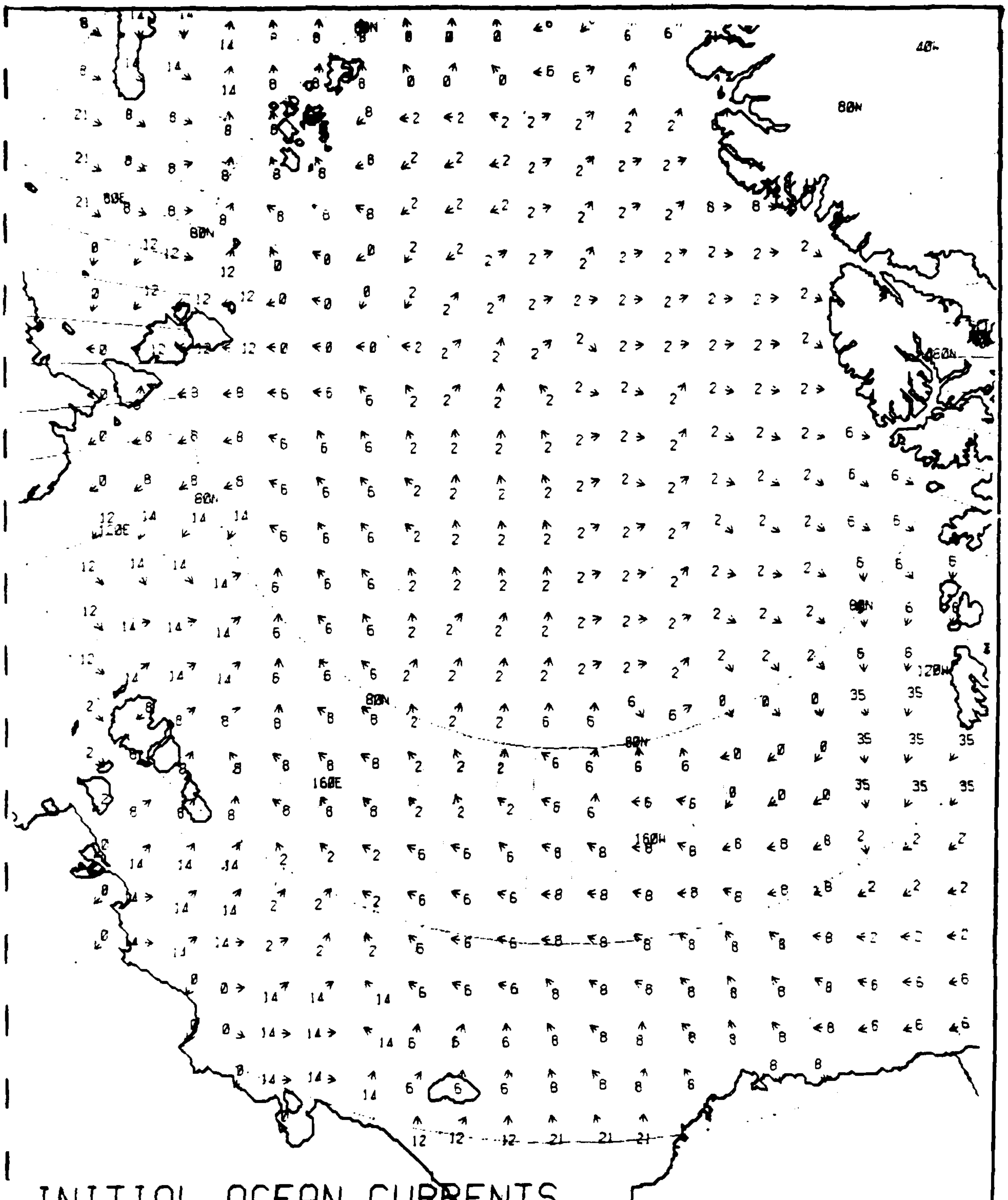


AVERAGE ICE GROWTH FOR DECEMBER
CONTOUR INTERVAL IS CM
LABELS ARE CM OF GROWTH PER DAY

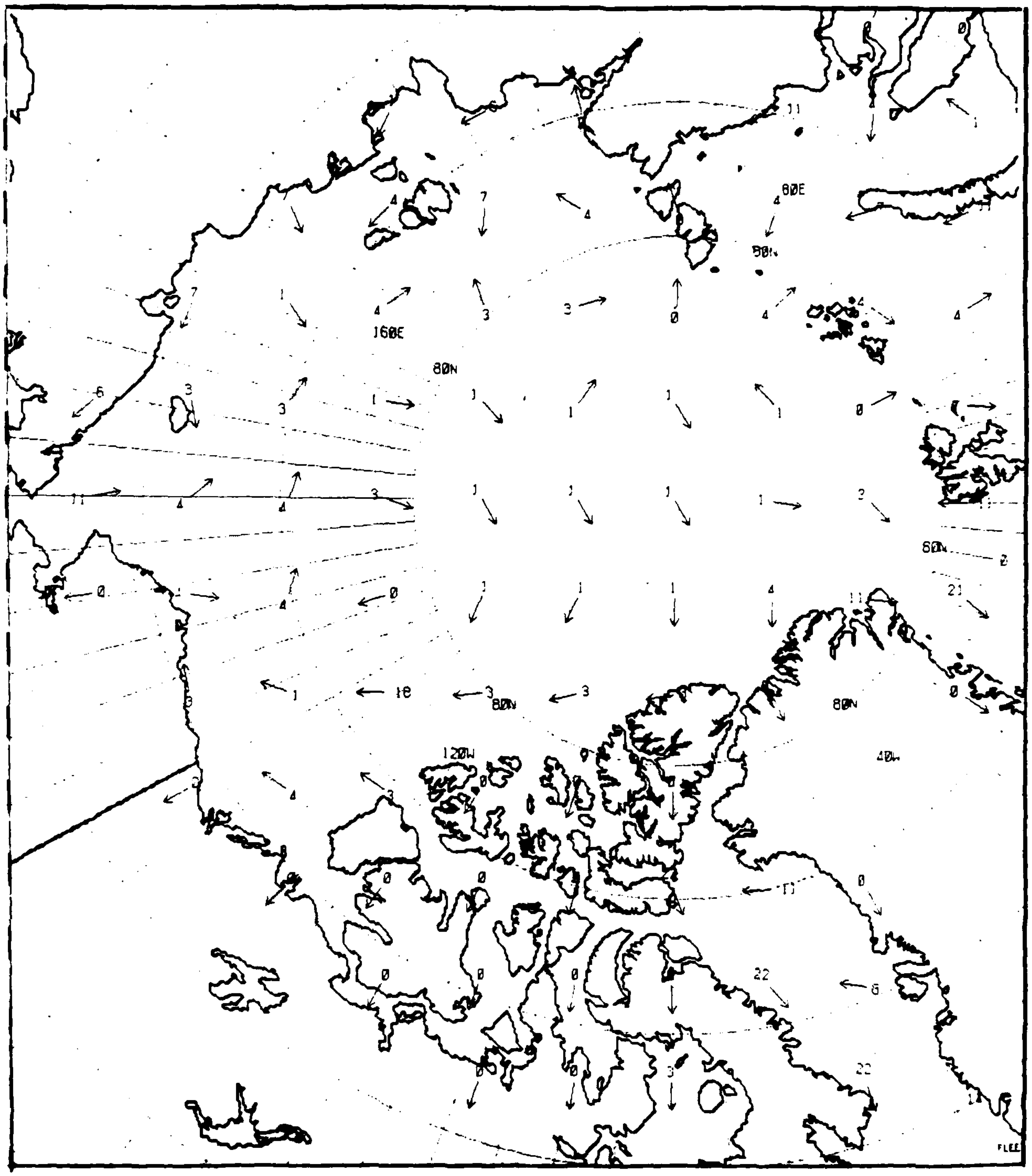

AVERAGE OPEN WATER GROWTH FOR DECEMBER
CONTOUR INTERVAL IS CM
LABELS ARE CM OF GROWTH PER DAY
FLEET NUMERICAL OCEAN
80N
120E
160E
160W
90N
+20
+12
+30
+10
+00

Appendix B

Ocean Current Data



INITIAL OCEAN CURRENTS



Ocean currents from the SKILES model (cm/sec.)

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER NORDA Technical Note 123	2. GOVT ACCESSION NO. AD-A114 407	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Report of FY81 Effort for PIFS-N Model		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) R. Wessel T. C. Pham P. A. Harr J. P. Welsh		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Control Data Corporation Monterey, California		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Ocean Research & Development Activity Oceanography Division, Code 330 NSTL Station, Mississippi 39529		12. REPORT DATE December 1981
		13. NUMBER OF PAGES 84
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Unlimited

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Polar Ice Forecast Subsystem, North
Empirical model
ocean surface
sea ice
ice pack
ice drift

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The ~~PIFS-N~~ model was modified to run in an operational format at FNOC. Changes were made in the model structure to allow easy interface with the FNOC operational data bases and CY203. Because of the new CY203, many aspects of the operational use of the machine were not yet decided or made public. In these cases a system was set up to simulate the operational interfaces of the PIFS-N model.

A more complete heat budget was added to the model and used for calculating the growth rates of thin and thick ice.

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S/N 0102-LF-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

A long-term simulation was attempted on the CY203. Several problems, associated with the initializing data, were detected and the run was stopped after two years of model time were simulated. Investigation into the initializing data showed inaccuracies in the surface wind data. Methods were outlined to solve these problems.

Problems which would affect the model performance upon grid expansion were also identified with methods of solution.